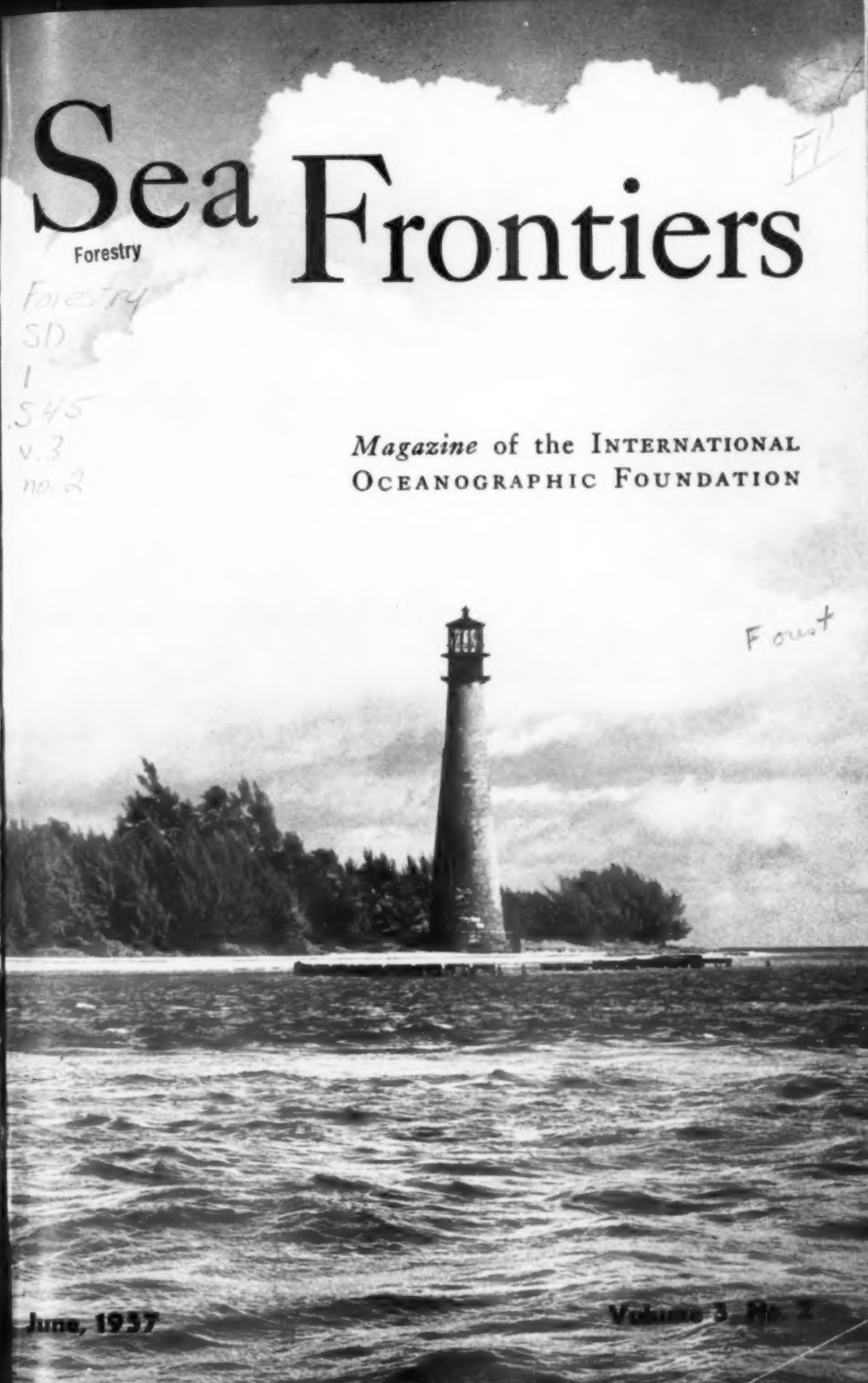
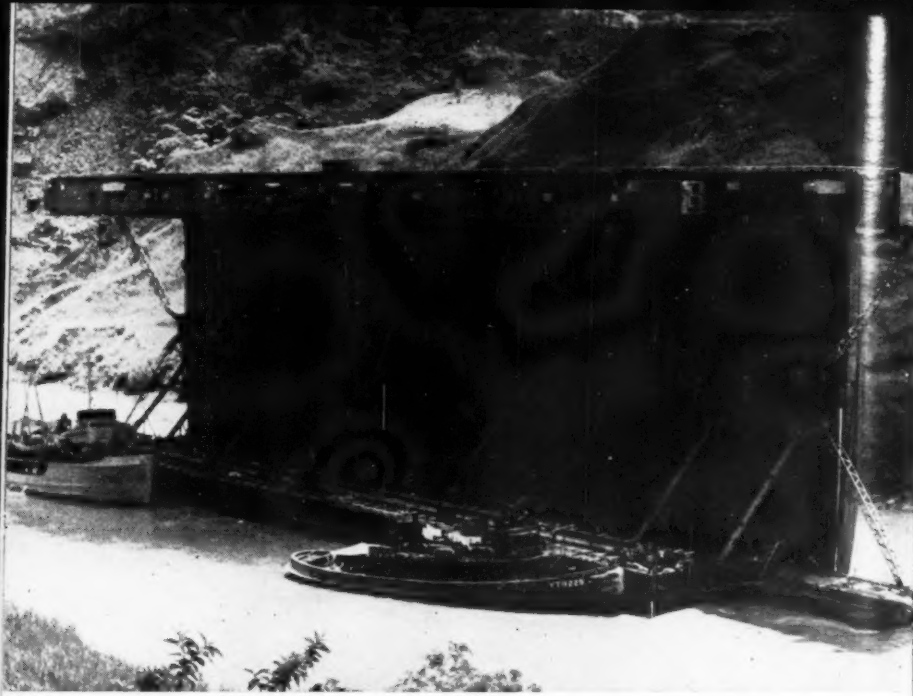
Sea Frontiers

Magazine of the INTERNATIONAL OCEANOGRAPHIC FOUNDATION



June, 1957 Volume 3 No. 2



A SHIP WIDER THAN THE PANAMA CANAL *floats through "on the beam." Too wide to traverse the Panama Canal, a Navy floating drydock was passed from one ocean to another by a novel device conceived and directed by officers of the Naval Civil Engineer Corps and carried out by Seabees under their command. After the passage the dock was righted again. Riding "on the beam," the dock is towed through Gaillard Cut in the Canal. The dock has the capacity to accommodate cruisers and large auxiliaries or several small warships at the same time. The plan of careening the dock on its beam end and towing it through the canal was simple but daring.*

FRONT COVER: HISTORIC OLD CAPE FLORIDA LIGHTHOUSE *tower on Key Biscayne, near Miami, Florida. It was the scene of a fierce battle during the Seminole Indian war. It was finally discontinued in 1878.*

SEA FRONTIERS

Bulletin of the INTERNATIONAL OCEANOGRAPHIC FOUNDATION

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Application for second class mail privilege is pending at Miami, Florida.

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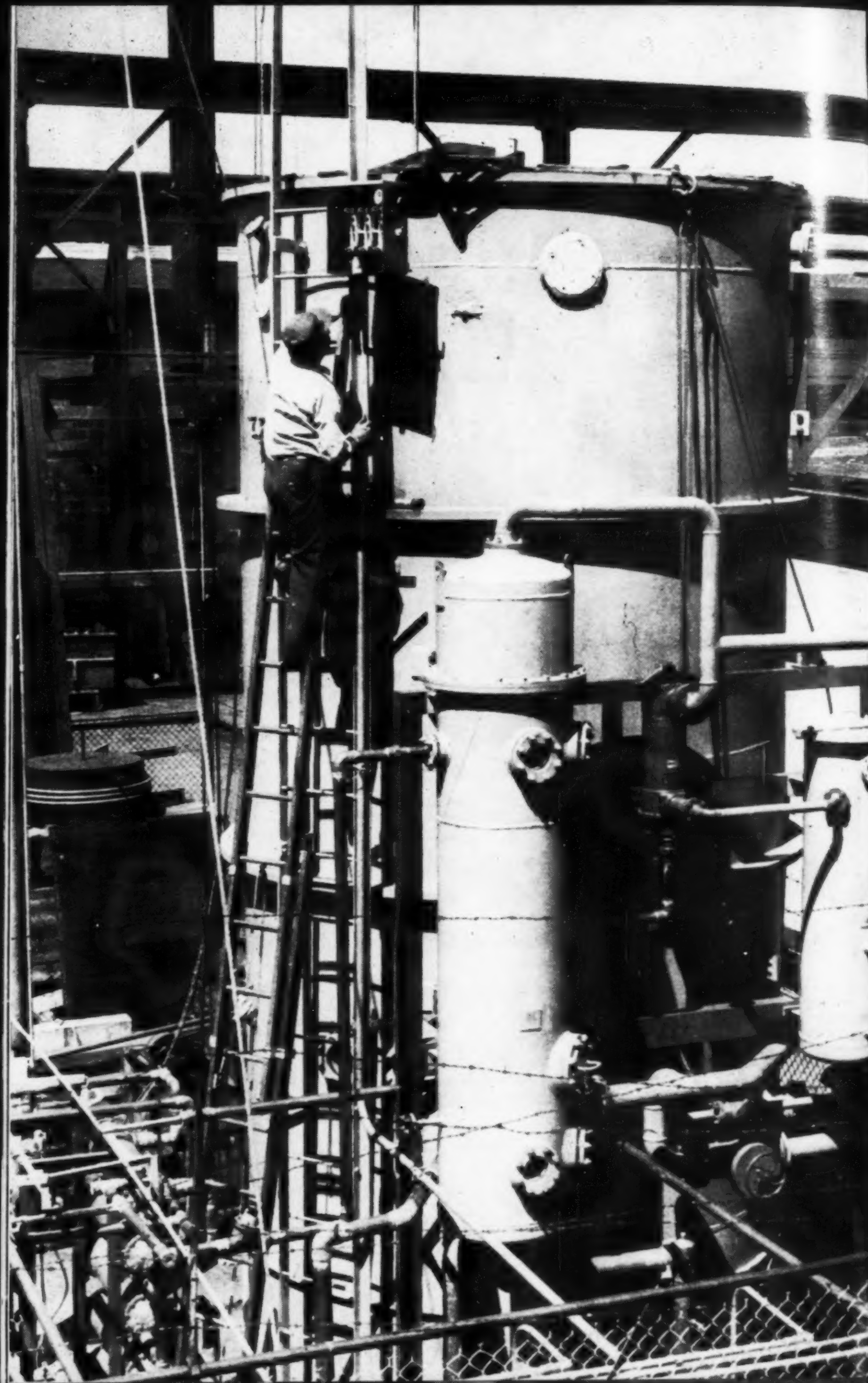

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Water from the Sea

By E. John Long

NEITHER AGRICULTURE, nor industry, nor man himself can long exist without that most important of all minerals—fresh water. In many places the need for it is becoming desperate: in the Great Basin of Nevada and adjacent parts of the United States and northern Mexico; in most of North Africa; in western India; in central Asia; and in western Australia.

Only two summers ago water was so scarce in New York City that special restrictions on its use became mandatory; in drought-stricken Dallas, Texas, 5 - gallon demijohns of drinking water sold in grocery stores for $1.25 in February, 1957.

Reservoirs Costly

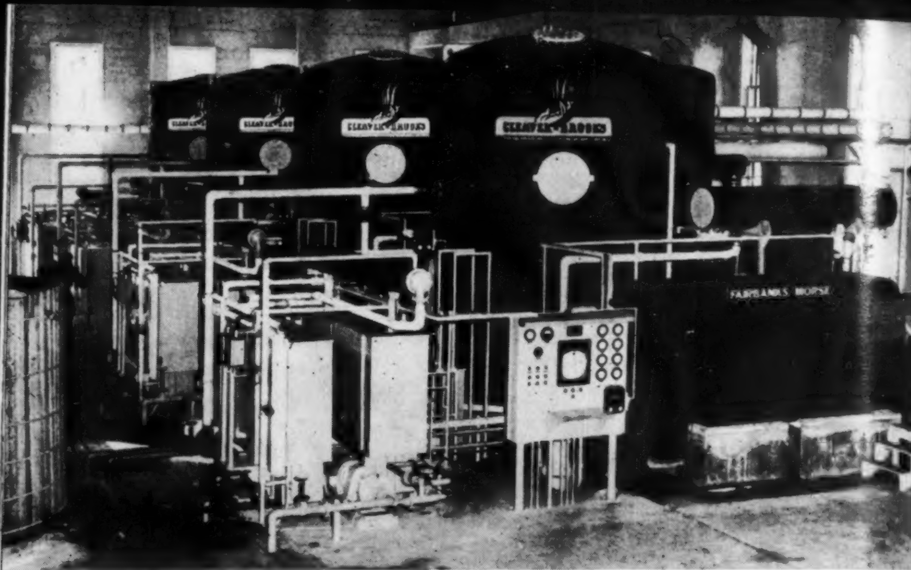
Yet engineers say the 1975 population of the United States will need about 453 billion gallons of water a day—almost twice the amount used now. Some of this increase will be met, of course, by increasing the number of reservoirs, large and small, throughout the land. The estimated 1975 demand, after all, is no more than a third of today's runoff. But dams cost money, and a reservoir holding a flood in Ohio cannot make up for a drought in Texas. Nor can we expect population to level off in 1975, any more than we can hope that runoff will increase.

So where do we go from there? More and more experts claim that there is only one practical solution—conversion of salt water from the sea, or from brackish wells or lakes of the interior. The idea of de-salting the ocean water at the shoreline, and then pumping it inland, is not new. The Office of Saline Water in the U.S. Department of the Interior, as well as several private corporations and laboratories, have been working on the prospect for some time. Several methods for such conversion have already been found. After all, the sea is the world's one huge reservoir of water, even if it is salt.

Cooperative Program

"In a couple of the methods," Secretary of the Interior Fred A. Seaton told the National Farm Institute at Des Moines, Iowa, in February 1957, "the estimated cost is now down to 60¢ for a thousand gallons. A third method can convert certain types of brackish water for about 40¢ a thousand gallons. Because of the progress that has been made, we could today supply you with converted sea water for less than the price you now pay for bottled mountain water. And we expect to keep on bringing the price down."

FRESH FROM SALT. *One of the modern methods of obtaining drinkable water from the sea is the Badger-Hickman Rotary Vapor Compression Still. A multi-rotor still, made of eight rotating drums, each eight feet in diameter. Rotary drums achieve a high rate of heat transfer and thus high efficiency. Under development at the Badger Manufacturing Co., Cambridge, Mass.*



ANOTHER METHOD OF MAKING SEA WATER DRINKABLE. *The illustration shows Cleaver-Brooks vapor compression sea water distillation units at Kindley Air Force Base, Bermuda. The total daily capacity of this plant is 200,000 gallons.*

The government's saline water research program is primarily one of cooperation with private groups by (1) stimulating the interest of private and public activities in this field, and (2) conducting scientific research and technical development through grants to and contracts with individuals and laboratories, and in government laboratories.

Five Major Approaches

What are some of the main processes that have thus far been developed under the government's saline water conversion program? Briefly they may be divided into five major groups: (1) Distillation, (2) solar. (3) membranes, (4) freezing, and (5) osmotic or solvents.

The usual water still for removing salt from sea water creates steam under high pressure. This steam is then carried into a condenser. High temperatures are also necessary to create enough pressure to get a large volume of water.

New distillation methods promise to produce fresh water at greatly reduced costs through multiple-effect stills in large sizes (several million gallons a day), and through vapor-compression equipment of rotary type in small sizes. Control of scale formation remains a problem. Flash evaporation units also hold possibilities, especially if adapted to utilize low thermal differences.

Putting Sun to Work

Solar distillation processes of various types show promising results, but chiefly in areas where the sun is sufficiently strong for efficient operation, such as southwestern United States, North Africa and Australia. Simple designs, rather than complex mechanisms using mirrors or focus-

ing collectors, are now favored. Still in the testing stage is a solar device with a dark plastic evaporating pan and a transparent film canopy supported only by air pressure. Heat from the sun evaporates salt water, and the vapor condenses on the inside of the canopy, running off into fresh water reservoirs.

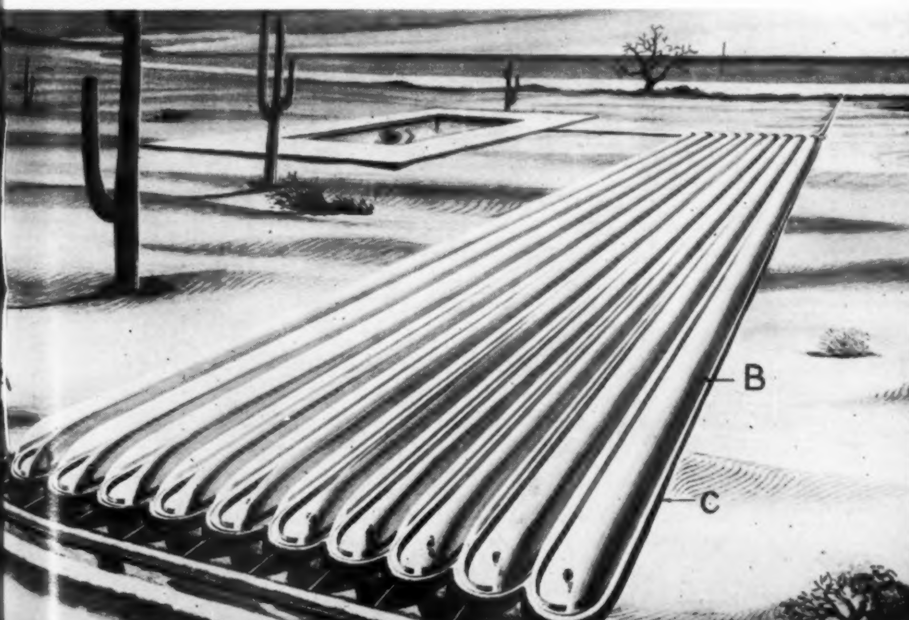
Another series of experiments is being conducted with electric membranes. A positively-charged electric pole, placed at one end of a pool of salt water, attracts the sodium ions of salt, while a negatively-charged pole, at the other end, draws the chlorine ions, breaking up the salt or sodium chloride. This process works best with brackish water, where tests indicate its cost would be about 42¢ per 1,000 gallons.

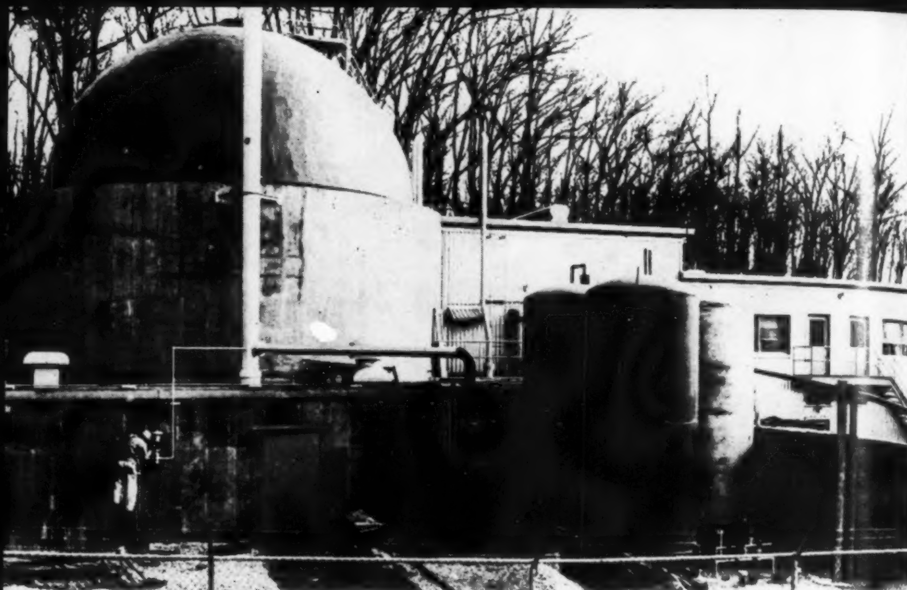
Freezing and Solvents

The original great hopes for an economical freezing process have not yet been realized. Salt water loses most of its salt when frozen, and, as it takes seven times as much energy to evaporate water as to freeze it, scientists expected that this might be a simple means of getting fresh water from the sea. Tests made thus far indicate that freezing processes are no more economical than methods using evaporators.

Research in the use of solvents discloses that tertiary octyl amine is an

SUN'S HEAT FRESHENS SALT WATER. *This solar still was made possible through duPont's development of economical and long-lasting plastic materials. One of these, a type of tetrafluoroethylene resin transparent film, will stand ten years of outdoor exposure. Each of the stills shown below is 100 feet long and two feet wide. They consist of a plastic evaporating pan (C), and a transparent canopy (B), supported only by internal air pressure. Sunlight, trapped between base and canopy, evaporates pure water from sea water, which is piped in at (A), from the ocean or brackish wells. The water vapor condenses on the inside of the canopy, runs down into collecting troughs, and finally into the reservoir at the top of the picture.*





THE DEVELOPMENT OF ATOMIC POWER *may play its part in the manufacture of fresh water from salt. General view of the Army Package Reactor looking north, with the vapor container at left. This type of plant was designed for use on remote islands where fuel is difficult to obtain. In such places it could well become the cheapest way of providing the energy for pumping and evaporating sea water.*

effective demineralizer, but progress in this field awaits the development of even more effective compounds, and better recovery of solvents from the residual brine.

Program Extended to 1966

So much for experimental work, past and present, being carried out under the provisions of the Saline Water Act of July 3, 1952. Experts believe that within the very near future the costs of large-scale distillation of saline water will be reduced to 50¢ or less per 1,000 gallons. When it can be reduced to 30¢ per thousand gallons — considered the maximum feasible for municipal use —the program might well repay the $10,000,000 that Congress has set aside for it. The program has been extended to 1966.

Another phase of the overall problem, but not included in the saline conversion program, is the power necessary to pump water from the sea and to send fresh water to industries, farms and homes wherever it is needed. For nearby use, local steam or electric power may suffice. But when the day comes that water must be widely distributed, as are oil and gas, by gigantic pipeline systems, atomic power plants will have to take up the load.

In April, the U.S. Army unveiled at Fort Belvoir, Va., a package power reactor developed jointly by the Atomic Energy Commission, the Corps of Engineers, and the Alco Products Inc., of Schenectady, N.Y.

While the Army designed this mobile-type unit for use on remote islands, desert terrain, or in the polar areas, similar plants could be set up where the cost of obtaining ordinary steam or hydroelectric power is excessive or uncertain.

"Cheaper By the Dozen"

The Army's pilot plant cost \$3½ millions, which admittedly is a bit steep, but like many other things, "they are cheaper by the dozen." When and if atomic reactors can be assembly-line produced, they unquestionably will fit into the sea-to-fresh water picture, not only for pumping power, but also to operate evaporators or other conversion process machinery. Cost is now definitely a limiting factor, both for the original plant and for the reactor fuel needed.

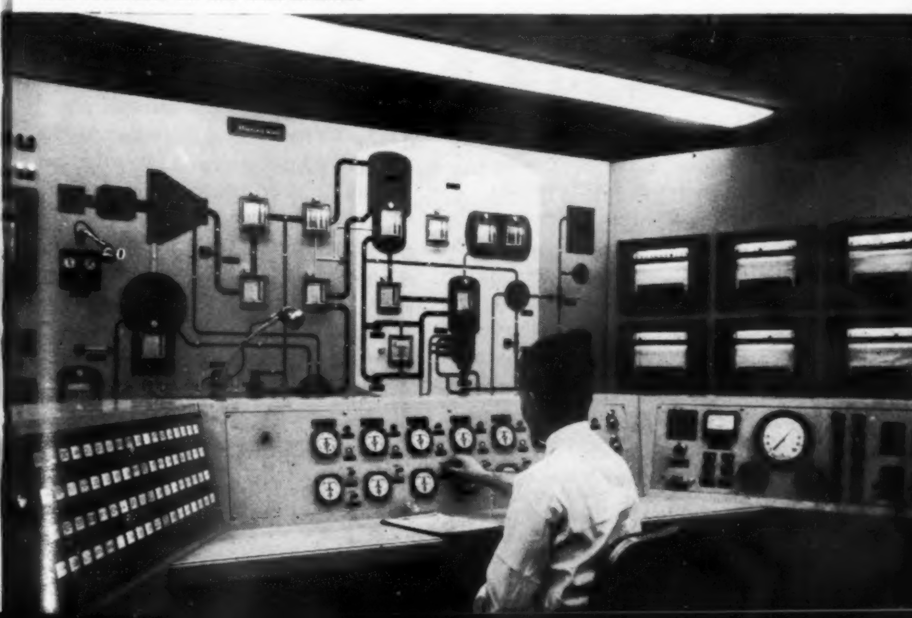
Meanwhile it is important to keep in mind the enormous drain on the fresh water resources of the world, a demand that is steadily increasing. Consumption in the United States, including industrial and farm uses, is estimated at nearly 1,500 gallons per person each day. Power plants alone account for more than a third of the industrial use—perhaps another argument for atomic reactors, which may require water-cooling, but can use sea water for this purpose.

Used Your 20 Gallons Today?

Individual use of fresh water, for drinking, bathing, laundry and other needs, now runs up to 20 gallons a day. Water engineers predict that even this high rate will increase about a gallon a day for every man, woman and child in the United States in the very near future.

Perhaps the most encouraging aspect of the expected water-shortage problem is a growing awareness of its serious consequences, plus a realization of the role that the sea can and

THE ARMY PACKAGE POWER REACTOR *is operated from this station in the control room, where a nuclear engineer observes all functions as they are read and recorded on the instruments.*



must play to abate it. Already certain water conversion experiments are being moved from inland laboratories to test sites along the seashore, where large-scale operations can determine if they are economical and feasible.

To scientists in general and oceanographers in particular the prospect is exhilarating. The *New York Times*, in a recent editorial, takes this optimistic view: "Ever since Malthus, the prophets of doom have forecast the decimation of the world's people by starvation. They could not have foreseen the possibilities of atomic power or of the inexhaustible sea."

Science Goes Deep

By G. Houot
Corvette Captain, Commander of the F.N.R.S. III
and J. M. Peres
Professor of Oceanography, Faculty of Science of Marseille

A glance at the history of submarine diving shows that the number of inventors concerned with it during the past centuries has been very large. Although many of the diving machines were highly fantastic, nevertheless some were remarkably well conceived. Solutions to the technical problems and the desire of man to penetrate deeply into an unknown world have not been lacking but, until recently, the mechanical and industrial means were not available for the construction of the necessary apparatus.

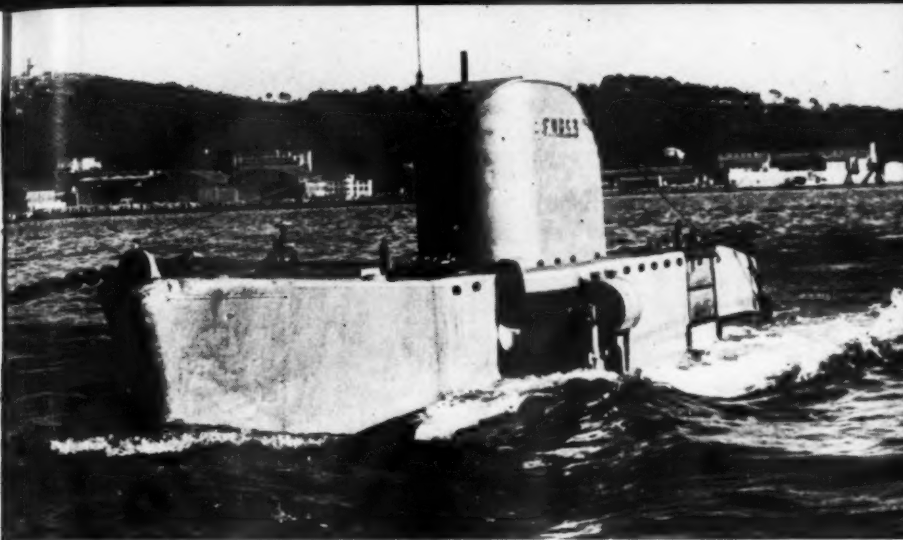
From Beebe to Piccard

It was not until 1934 that the American William Beebe and Oris Barton succeeded in descending to 3,028 feet in a sphere suspended from a cable. Some years later, the Swiss professor Auguste Piccard, of the University of Brussels, in collaboration with Professor Cosyns, and with the financial contribution of the F.N.R.S., the Belgian National Fund for Scientific Research, succeeded in making the first diving machine capable of reaching a depth of 12,000 feet without any form of suspension. This he christened the Bathyscaphe.

A Second Attempt

The difficulties encountered and the eventual failure of this first attempt did not discourage him. A new undertaking was planned, this time with collaboration between the Belgian F.N.R.S. and the French Navy. This enterprise has resulted in the construction of *F.N.R.S. III*, the first apparatus adequately planned for a scientific exploration of great depths.

The Bathyscaphe is made essentially of two parts, the sphere and the float. The sphere is the brain of the apparatus. It is this which carries the two passengers, the pilot and the observer. In order to withstand the very great pressures which exist in great depths, it was made of special high



THE FRENCH BATHYSCAPE, *while being towed. She has a superficial resemblance to a submarine. The visible part is actually the float. The diving sphere is suspended beneath it.*

strength steel. It is 6 feet in inside diameter and about 4 inches in thickness with a weight of 11¼ tons. The steel door has an opening about 15 inches in diameter and two portholes, of which one serves for observation. These portholes are made of tapered plexiglass plugs, 6 inches thick and 4 inches in internal diameter.

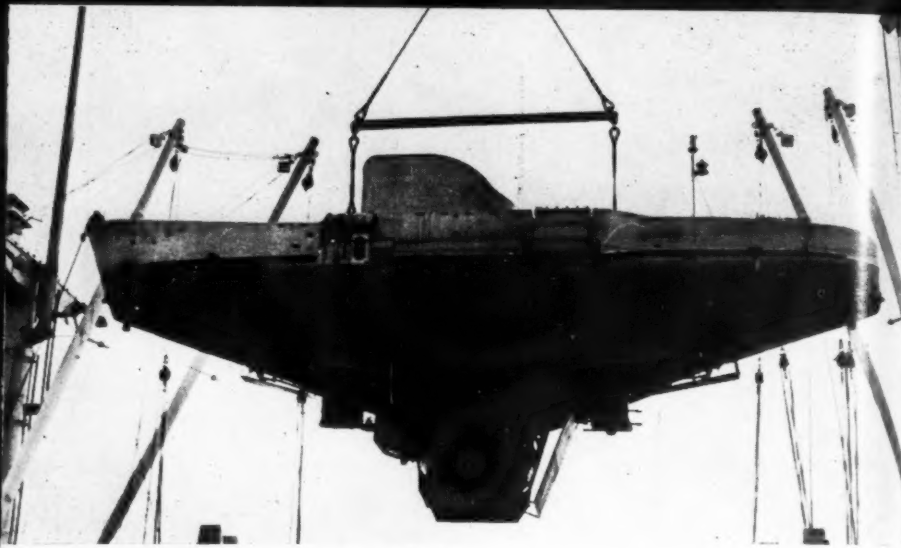
Six Ton Cabin

The sphere, immersed in water, weighs 6 tons. If it were set loose in the sea, it would inevitably sink without hope of recovery. The whole principle of the apparatus lies in its attachment to a buoyant unit, the "float," which retains considerable buoyancy at any depth. Sphere and float are permanently joined. The float must be large enough to counteract the weight of the sphere and to bring it back to the surface, no matter what happens. Unfortunately there is no solid material with great buoyancy and the compressibility of gases makes them useless. So we turned to liquids and, naturally, to the lightest of them, gasoline.

Maneuvered by Ballast

The float is nothing but an enormous reservoir, divided into compartments on the inside in order to reduce accidental loss. It contains about 10,000 gallons of gasoline. This liquid has the additional property of not mixing with water. A permanent passage between the inside and outside of the float provides continuous communication between the gasoline and the sea water. Thus. the steel sides of the reservoir are not subjected to strain in diving and, in contrast to the sphere, are made of thin, light material.

The whole operation of the machine is a simple application of the Archimedes principle. In order to make the Bathyscaphe sink it is made



THE DIVING CHAMBER *can be seen below the boat shaped hull of the float.* F.N.R.S. III *is capable of descending to a depth of several miles beneath the surface.*

heavier and in order to regain the surface it is lightened. This is accomplished by means of ballast. The initial excess weight is provided by filling a reservoir with water. At the surface this is normally empty. Immediately before diving, it is opened to the sea. To simplify construction, this reservoir, of about 27 cubic foot capacity, is used as a shaft or "lock," giving access to the sphere. The latter is always under water.

Electromagnetic Safety Controls

In order to lighten the apparatus, iron shot contained in vertical hoppers are released. These are held solidly in place when magnetized by an electromagnet. Breaking the current allows them to flow out. This principle guarantees safety, since any electrical breakdown causes the discharge of the ballast. The weight of the ballast, over 4 tons, may seem considerable. It is needed because the volume of the gasoline becomes less and its density increases in the course of a dive, due to increased pressure and reduced temperature. The loss of buoyancy is thus relatively large in the course of deep dives and the 4 tons are not excessive for providing a return from depths of 12,000 feet.

For reasons of safety, there is also supplementary ballast, to be used in the case of accidents, especially a leakage of gasoline. This is also secured by electromagnets so that an electrical breakdown will cause nothing worse than a premature return to the surface.

Auxiliary Equipment

The machine has numerous accessories, some of which are used in piloting, others in observation. The more important ones are listed below:

Air purifying apparatus. These are cylinders of oxygen and cartridges of soda lime.

The gauges which show the quantity of iron shot in the hoppers.
The gauges of gasoline and water level, which make it possible to maintain the proper pressure equilibrium.
The detectors of water leaks.
Pressure gauges indicating depth.
Temperature gauges for both gasoline and sea water.
The compass.
The depth sounder. This makes possible a gentle approach to the bottom and landing without shock.
Apparatus for communicating with the outside world; radiotelephone on the surface, ultrasonic equipment during the dive.
All this material is in the sphere and is operated along with the electromagnets by a set of storage batteries.

Self-propelled

On the outside there are two propulsion motors which provide horizontal movement, during the dive and at the bottom of the sea. There is also a group of six searchlights of 1,000 watts each, illuminating all the area visible from the porthole. They are served by a second battery of accumulators situated outside the sphere, simply immersed in oil and open to the sea pressure. More specialized scientific equipment has also been added:

An electronic flash and two automatic photographic instruments controlled from within the sphere. These were made by Professor H. Edgerton of the Massachusetts Institute of Technology.
Apparatus for moving pictures.
Bottles for obtaining water samples controlled by electromagnets.
An apparatus for automatically and continuously recording the temperature of the sea in course of being perfected.

Diving Below 12,000 Feet

By diving to 12,150 feet on February 15, 1954, the Bathyscaphe *F.N.R.S. III* ended its trial period. Shortly afterwards, an agreement between the National Center for Scientific Research and the Navy settled the problems of scientific and routine operation. An administrative committee, under the distinguished presidency of M. Fage, a member of the Institute, was created to decide the program of work.

Since its construction, *F.N.R.S. III* has made forty-eight dives. This figure speaks well for its safety. The various trips made to Dakar, to Paris for the exposition at the Salon Nautique, and to Lisbon recently, are proof of its durability. Of course, it is far from perfect and our grandchildren will doubtless smile when they see it, but it is the first machine of a series of offspring which will continue to grow in the immense achievement of opening the door to the great deeps.

A New Oceanographic Tool

It is obvious from its description that the Bathyscaphe is a marvelous instrument for oceanographic work. Up till now, eighteen dives have been made with biologists and they have already produced important though fragmentary results.

Critics of the Bathyscaphe may say

that the results are insignificant. This would be both incorrect and unjust. A new machine and a new technique, no matter how perfect, cannot be expected to revolutionize a complete science overnight. Think of the years which were needed to make possible submarine photography in great depths, or even to develop an instrument as intrinsically simple as a bottom sampler. Scarcely two years have passed since the testing was finished and the Bathyscaphe ready to go to work.

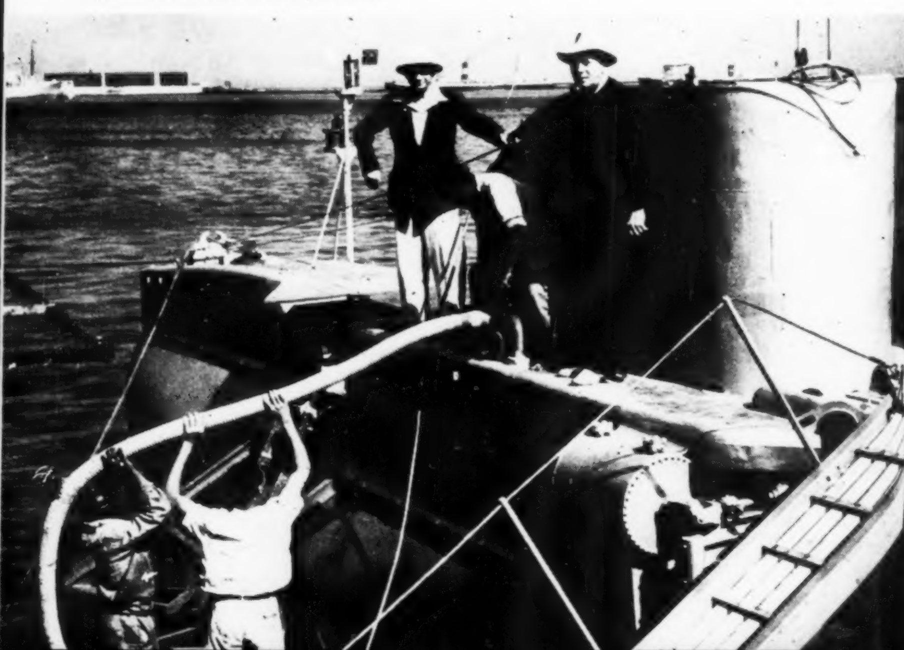
Two Years of Discovery

Let us review, very objectively, the results obtained in the course of two years of research. Luck did not favor the first users of the Bathyscaphe. After the first biological dives made near Dakar by Prof. Th. Monod, a dozen consecutive dives were completed in the Mediterranean. But the Mediterranean is one of the least suitable seas for the Bathyscaphe. Forbes, a century ago, tried trawling in its depths and found them so barren that he concluded that all deep seas are lacking in animal life.

Mediterranean Depths Almost Empty

Even if all the deep waters of the Mediterranean are not as barren as Forbes thought, they are very poorly populated. The French oceanographic vessel *Calypso* has made thousands of deepwater photographs in the Mediterranean, with the Edgerton camera. The published photographs are the exceptional ones, with something to show, but the vast majority showed nothing except mud in which are hidden infrequent specimens of *Abra longicallus, Dentalium agile, Siphonodentalium quinquangulare* and several other common deep bottom molluscs. One reason for this sparsity is,

FLOTATION IS PROVIDED *by filling the float reservoirs with gasoline.*

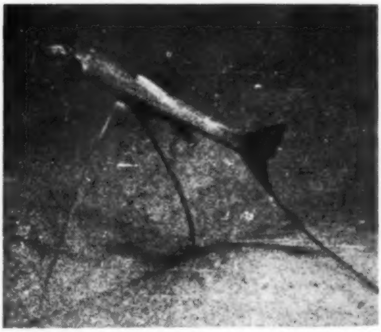


of course, the fact that the Mediterranean is over 14,000 feet deep in places and has no connection with the ocean except the Straits of Gibraltar. The Straits are very narrow, seven miles across, with a shallow sill of about 1,000 feet depth. This lack of communication with the ocean results in very poor circulation of the deep Mediterranean waters. The plankton is also less dense than that of the nearby Atlantic. Scarcity of deep-water animal life in the Mediterranean is basically a question of lack of plankton food, both from actual insufficiency and also because of poor distribution.

Fish Walks on Tentacles

As far as bottom life is concerned, then, the Mediterranean dives have given limited results. Animals seen in midwater from 400 feet to 6,000 feet in depth are also few and of interest only to specialists. Some very rare deepwater fishes were seen, such as *Haloporphyrus* and also the very strange *Benthosaurus*. In the latter, the long prolongations of the fins were previously thought to be sensory organs, but it now seems that they are used for support.

THE DEEP SEA FISH Haloporphyrus, *photographed on the Mediterranean sea floor, over a mile deep.*



THREE POINT LANDING *is apparently the purpose of the long rod-like extensions of the fins of* Benthosaurus, *as photographed from the Bathyscaphe at about 7,000 feet depth. Previously it was thought that the antenna-like projections were sensory organs. Its first photograph taken on the sea floor shows that the fish walks on them.*

At the time of the two first test dives, when unfortunately no biologist was on board, a fair number of dogfish were seen, some about 6 feet long. Doubtless the visit of the Bathyscaphe had alarmed them, because they were never again seen. For plankton studies, the Mediterranean dives brought valuable lessons in the vertical distribution and in the natural appearance of various free living creatures.

Sea Snowstorms

G. Houot and P. Willm gave particular attention to what they called "snow." During a dive, on arrival in the darker depths, the searchlights, shining from above down, brought into view an immense number of small particles, apparently stationary

in the water and with a decided resemblance to snowflakes.

It seems that the particles consist principally of small planktonic Acanthids, but with some clumps of Coccolithophorides and even flakes of dead organic material derived from the dead bodies of plankton. The thickness of the "snowfall" varied in relation to the depth.

Success off Portugal

To increase the scientific production of the Bathyscaphe the French National Center of Scientific Research has supported a research cruise in the Atlantic on the Portuguese coast, where relatively great depths are found near the shore. Thanks to the help of the Portuguese authorities, we made six dives, of which five were a complete success; three were in the the canyon of Setubal, south of Lisbon, from 1,800 to 5,000 feet in depth. Two were outside a canyon on the Atlantic slope immediately to the north of the mouth of the Tagus. This cruise has given results of considerable interest and rich populations of bottom living animals were found.

Undersea Gardens

We were astonished by the unsuspected variety and number of certain bottom living populations. At 5,000 feet in the Setubal canyon we dropped down upon a bed of vari-colored sea anenomes forming a colony 6 feet square. The variety of colors was entrancing, going from whites and yellows of the gorgonians to the violet of the *Kophobelemnon stelliferum* and including the red plumes of *Bathypenna elegens* and

THIS STRANGE FISH, *looking like an eel, is called* Halosaurus. *It was photographed on the deep sea floor off the coast of Portugal, during one of the descents of the Bathyscaphe.*

the brown bouquets of the cerianthid tentacles. In the midst of the mud plain, decorated with these multicolored "flowers," large violet aristeid shrimp, 9 inches long, swam by, while on the bottom, were crawling sea cucumbers, zoroasterid starfish and the like.

The fishes included numerous specimens of *Halosaurus johnsonianus,* which looks a little like an eel. It glides near the bottom with its body at diving angle, its snout in the sediment, and its tail rhythmically undulating. We have seen also the *Macruridae Trachyrhynchus scabrus* and especially the strange *Hymenocephalus longifilis,* whose pectoral and pelvic fins have the first ray threadlike and elongated, which the creature seems to drag some distance from the bottom. The similar threadlike ray of the dorsal fin is not dragged behind the fish, as was thought, but is recurved to the front, projecting well beyond the snout.

Deep Sea Lilies

Among other interesting creatures were sea lilies of the genus *Rhizocrinus* at 7,000 feet, growing erect

above the mud on their foot long stalks. This gives the lie to the theory that the stalk is used to support the head on the surface of a liquid mud, covering the deep sea floor. Such a substrate has never been seen from the Bathyscaphe.

A 2,000 foot dive showed the very curious attitude of the shrimp *Nephrops*, lying in wait in a kind of burrow, from which only the head end and pinchers projected.

Observations were also made on creatures in the waters above the bottom. It was possible to distinguish some general features of the vertical distribution of these organisms. All the dives were made between morning and midday. There consistently appeared three distinct zones. There was a well populated surface zone extending down to 400 feet, with the maximum usually from the surface to 150 feet. Another zone ran from 400 feet to about 1,200 feet and was lacking in both small and large plankton. In the zone from 1,200 feet to 2,500 feet, the plankton again became rich and abounded with Narcomedusan jellyfish *Solmissus* and little hatchet fishes or mycotophids. Incidentally, we have never seen their so-called luminous organs emit the slightest gleam. Perhaps the poverty of the layer between 400 and 1,200 feet may be due to the fact that, in day time, a large number of pelagic animals seek refuge in deep water, mostly from 1,200 to 2,500 feet. They only come to the surface at night.

Beyond 2,500 feet the free swimming life thins out, especially about 3,500 feet, but it always shows a small maximum in the 500 feet immediately over the bottom. Plankton is distinctly richer in the canyon, where strong currents have been seen near the bottom, than it is over the Atlantic slope outside.

Future Oceanography and the Bathyscaphe

It is impossible to give here a good idea of all that we have been able to see, since the report on biological operations for the Portugal expedition alone covers forty pages. We hope that this article will give to readers in other countries than our own, some idea of the immense possibilities for oceanographic research which the Bathyscaphe opens up. Even in its present imperfect state, *F.N.R.S. III* has already permitted us to watch the natural behavior of the animals of great depths, alive and in their natural habitat. Only Beebe and Barton have hitherto seen this and then only down to about 3,000 feet. Thanks to the Bathyscaphe, the voyage of a biologist to the great deeps is now a practical reality and not an exceptional feat of daring. Tomorrow a new and larger Bathyscaphe, drawing from the experience of *F.N.R.S. III* and better equipped will go down to the greatest depths known. Tomorrow this world of the abyss which *F.N.R.S. III* has opened up will be almost as easily studied as a meadow or a pool of water left by the receding tide.

Mississippi's Only Marine Laboratory

By Gordon Gunter
Director, Gulf Coast Research Laboratory, Ocean Springs, Mississippi

On a 40-acre tract covered with large moss-grown trees is the Gulf Coast Research Laboratory. Nestling on the shores of Davis Bay and very close to Mississippi Sound, it is two miles east of Ocean Springs, where, in 1699, the French first settled in what is now known as the original Old Biloxi.

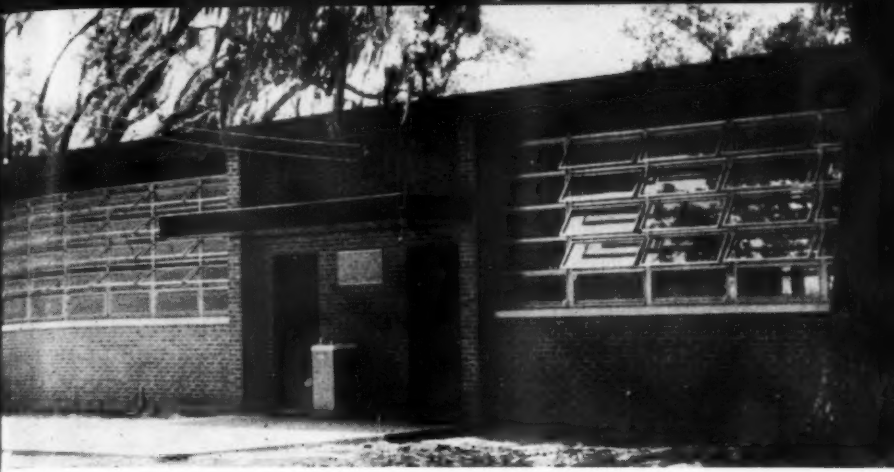
Except for a few scattered homes to the west, the laboratory is in a relatively untrammeled area. A variety of wildlife inhabits the nearby woods and occasionally ventures onto the laboratory grounds. Alligators sometimes swim up and down the boat slips, and tree frogs have been known to cluster upon the green doors of the buildings. Small crabs, *Sesarma,* wander all over the grounds and far back into the woods. They climb the outer walls of the laboratory and often come inside.

Marine laboratories are not born easily. Usually they have their inception as glimmers of hope in the minds of progressive men and this was true with the Gulf Coast Research Laboratory on the Mississippi coast. The gestation period extended from 1934, when Dr. R. L. Gaylor first came to the coast on a collecting trip, to 1947. During that period a group of devoted men within the Mississippi Academy of Sciences promoted the idea.

In the meantime, Doctor Gaylor made summer field trips to the coast with his classes from Delta State College, and in the spring meeting of 1947 the Academy organized the laboratory and classes were taught during this first summer without financial support. The Board of Trustees of the Institutions of Higher Learning gave support in 1948 and, in 1950, the legislature formally established the laboratory.

The present site of the laboratory was purchased in 1950. This 40-acre tract had a large home and two smaller buildings on it. Surplus Army buildings were moved in to be used as laboratories and dining hall. Dormitories were constructed from surplus property materials during the same year.

From 1947 to 1952 the laboratory operated only in the summers as a teaching laboratory. It was under the direction of Dr. Gaylor. However, the need for a continuous research program led to the appointment of Dr. A. E. Hopkins as the first resident director in 1952. He initiated a building program which was continued after his demise in February, 1955. The writer became director in September, 1955.



ENTRANCE *to the modern laboratory building at Ocean Springs.*

Laboratory Serves Whole State

The Gulf Coast Research Laboratory is administered by the Board of Trustees of Institutions of Higher Learning, which administers all state-owned colleges in Mississippi. Thus, the laboratory is associated with the entire college system. Students come from all state colleges and are given resident credit for courses by their home institution. This same arrangement can be made by privately supported institutions and Millsaps College at Jackson, Miss., has made such arrangements.

Louisiana State University carried on its summer marine program as a joint operation with the laboratory this summer. It paid the salaries of its own instructors and thus contributed toward operational expense. Both Mississippi and Louisiana students took the courses.

Mississippi's Only Marine Laboratory

The laboratory is unique in the Gulf of Mexico area in that all marine interests of Mississippi are funneled through it, which means that there is unity of effort. It is the research laboratory for the Mississippi State Seafood Commission and the director is a consultant to that body. Purchase of the site and most of the recent building program was financed by the commission. The laboratory also has cordial relations with the Gulf Exploratory Fishing Unit of the U. S. Fish and Wildlife Service at nearby Pascagoula. Their deep water trawling and dredging operations have considerably enhanced the laboratory's collection of deep water marine animals.

Biloxi Bay and Mississippi Sound are estuarine areas where the salt content of the water is below that of sea water and where large oyster reefs exist. These shallows are the rearing grounds for a great many species of fishes, shrimps and blue crabs. The lowest relatives of the back-boned animals, the acorn worm *Balanoglossus,* and its relatives are abundant along the bay shores. Farther out

a chain of islands separates Mississippi Sound from the Gulf of Mexico. Here the water is saltier and a great many more animals such as sand dollars, starfish and squid are to be found. Along these island beaches, *Amphioxus,* the lance-shaped lowly relative of fishes, is also found in abundance.

World's Largest Catfood Factory

The Mississippi coast is less than 70 miles in length and yet it is the center of a thriving seafood industry. It produces more marine products than any other gulf state, with the exception of Louisiana.

It lies very close to the largest shrimp fishing grounds in the world and the world's largest natural oyster beds, the "Louisiana marsh," east of the Mississippi River. Shrimp and oyster canneries operate in Gulfport and Biloxi, and menhaden factories operate at Pascagoula. There, also, the world's largest cat food factory uses a variety of fishes in its operations. At Gulfport a new but thriving marine aquarium has large numbers of fishes and porpoises on exhibition. The Laboratory works in cooperation with this operation. These various natural advantages make the location almost ideal for the student of marine life. Different but equally important advantages make it of interest to students of marine geology.

"Dealings In Dirt"

The physical plant consists of ten

INTERIOR *of Mississippi's marine laboratory. Experimental aquaria on the left and work benches on the right.*

buildings. The large home, which was present when the site was purchased, is used as a faculty residence. The local statistical branch of the Fish and Wildlife Service also has an office in this building. The large downstairs living room is used as a seminar hall. A small wooden building is a "mud" laboratory for the geologists, where the motto is "Clean dealings in dirt." There is a small residence for the director and for the caretaker.

A large, well-equipped wooden dining hall takes care of the needs of students and the staff during the summer. Board and room is $15.00 a week. This is cheap but it does not indicate any attempt to economize on the dining room, which is run by a professional cook. On the contrary, the Laboratory is proud of this operation because there have been no complaints about the food and large, active men gain weight on the fare. There are two, two-story dormitories, one for men and one for women, which can house twenty students each. Some faculty members prefer the dormitories to the faculty residence and reside there when there is enough room. Out-and-out vacationers are not welcome but professional workers are given housing and laboratory facilities free during their visits to the coast. Quite a number of people have taken advantage of this situation. The Laboratory is repaid by the research work done. Additionally, field trips of biology and geology students come to the coast throughout the year. These classes are usually lectured to by the Laboratory staff and have use of the station boat and other facilities.

The first laboratory was an old barracks building, which was nevertheless fully equipped with four lead-lined water tables, running sea water and other accessories, making a fairly well equipped marine laboratory. It is still in use. This building also houses the marine invertebrate collection and a large collection of fishes. It is used by state colleges for the teaching of freshman biology at night during the winter.

Main Buildings

The main laboratory buildings are the Research Laboratory and the Teaching Laboratory. The Research Laboratory is a well equipped brick building with four water tables and seven working tables for senior investigators. The main offices are in this building. The Teaching Laboratory is a new brick building of modern architecture which was put into operation on June 1, 1956. It has eight water tables with special lights, running sea water, running fresh water and compressed air outlets. There is table space and lockers for 56 students. A smaller laboratory with desk and table space for sixteen students was originally planned as a botany laboratory and it has no water tables. There is also a small library room.

The station boat is a new all-steel trawler, forty feet in length, powered by a diesel engine. It is equipped with a winch for the operation of dredges and trawls. It will carry about twenty people, including the crew. It is made

with water tight compartments and is relatively unsinkable.

The general location, equipment and facilities of the Laboratory are excellent, but things are never perfect. The Laboratory is quite deficient in a library. Therefore research papers, reports and reprints will be gratefully received.

Teaching and Research

The Laboratory arose because various teachers of the State felt the need to instruct their students in the marine phases of the various sciences. At present all teaching activity is devoted to marine zoology and marine geology. With one exception all courses given are advanced and require considerable background. The courses taught are Marine Invertebrate Zoology, Marine Vertebrate Zoology, Problems in Marine Zoology and thesis courses for the master's degree, which may be taken through Mississippi Southern College and the University of Mississippi. In geology there is an introductory course in Marine Geology and Problems in Sedimentation. These courses are taught at a senior and graduate level, so that they may be used as credit towards master's and doctor's degrees. Some universities require a course in marine biology as a part of the program for the Doctor of Philosophy degree. Students at the University of Illinois and other places may fulfill that requirement by summer work here. Finally, a course carrying graduate credit in Education or introductory credit in Zoology, called Zoology for Teachers, requires no biological background. It is taught by Louisiana State University and is open to students of Mississippi colleges. In the future it is planned to give courses in marine botany and physical oceanography whenever there is enough demand.

The summer teaching staff is made

AMPLE WINDOWS *provide good lighting for research in the Ocean Springs Laboratory.*

up of men who are professors of geology at Millsaps College or professors of zoology or biology in Mississippi Southern College, the University of Mississippi, Louisiana State University and the University of Illinois.

Gulf Fishes Listed

The first task of any marine laboratory, in which biology plays a part, is to find out what marine organisms live in the region, and to list them for the benefit of all future workers. To date the Laboratory staff has published twenty-seven notes and short papers on the local flora and fauna. This survey job is by no means complete and is still in progress. Mr. Donald R. Moore is paying particular attention to the starfishes, sand dollars and their relatives and also to the Mollusca. In the latter group there are many small snails and bivalves, some no larger than big protozoa, which are to be found everywhere in the sand but which are usually neglected. Mr. Moore has found 300 species in the Gulf, many of which are new.

Dr. H. H. Shoemaker has gathered, in the past several years, the most complete collection of Gulf fishes of any marine station. Most of these will be listed in a forthcoming work on the fishes of Mississippi Sound. Some interesting recent acquisitions are a large headfish, whose skin weighed more than its muscles, and a female deep sea angler with three small parasitic males attached.

Eggs Hatched From The Mouth

Dr. J. W. Ward of the University of Mississippi Medical Center has worked for several summers upon the marine catfish, *Galeichthys felis,* the male of which takes thirty or so of the large eggs in its mouth and incubates them until the little catfish are hatched. During this time, which covers a period of approximately two months, the males do not feed at all and become emaciated. Doctor Ward has been successful in fertilizing these eggs in the laboratory and has been able to work out the very earliest cleavage stages. These catfish eggs are among the largest known for any bony fish and their process of development is considerably different from the ordinary fish. The early development of these little fish has not been fully described and it is of considerable interest to scientists who can use it for fundamental studies in nerve physiology.

Secrets of a Snail

Mr. William J. Demoran has been working upon the marine snail, *Thais,* which bores into the oyster by means of a very complicated little ribbon of teeth called a radula. This queer but efficient apparatus is mounted on a cartilage frame and, with its attendant muscles and nerves, is a very complicated mechanism. Nevertheless it was discovered that if the mechanism were cut off from the animal, where it lies at the end of a tube called the proboscis, it would be regenerated within two to three weeks. This appears to be the most complicated organ any animal can regenerate and the fact raises some immediate questions concerning the problems of morphogenesis. Biolo-

gists are still very much in the dark as to how the small blobs of protoplasm called eggs will differentiate and grow always into elephants, oak trees, whales or human beings. Students of morphogenesis are trying to pry into the reasons why and how living material is organized so that it goes through various stages of development, becoming ever more complex and finally ending in organs which are extremely complicated. It is possible that *Thais* affords a new and simple material which will lead to further progress in these fundamental studies.

New Methods Devised

Since 1948 the geologists at the Laboratory have been studying how the sediments from land are deposited in the bays and what effects the different temperatures and salinities have upon this process. They have learned that a flocculent iron-alumina gel lies close to the bottom in the bays and that it acts as an absorbent for nitrates, nitrites, and phosphates, the chief nutrient salts for most of the micro-plankton growing in the water. They have also devised methods, which utilize the vacuum principle, for picking up the very surface layers of the sediments without disturbing them by the usual coring process. They have found that the methods of sampling and analyses, commonly used in sedimentation studies, do not work very well for the turbid waters and mud bottoms of this coast, and they have had to devise new methods.

These are examples of the research work being done at Ocean Springs. Other things are going on but they are not complete. The research staff itself is quite small, consisting of three full-time workers. Their efforts are supplemented during the summer by visitors from various colleges and universities, mostly in the South. Progress has been modest but respectable considering the fact that the Gulf Coast Research Laboratory is financially a small operation. The best thing to be said is that the physical facilities are present and the interest generated is sufficient for a greatly expanded marine program for the northern Gulf of Mexico in the future.

NOT FAR FROM BILOXI, *the laboratory is beautifully situated on the Gulf of Mexico and screened by trees.*

THE SEA SNAKE *as Olaus Magnus pictured it several centuries ago.*

Sea Snakes Are Real

By F. G. WALTON SMITH

OF ALL THE SEA MONSTER legends, that of the sea serpent is the most hardy. Many of the earlier sea monsters have given way before ridicule or have died a slow death as scientific advances and the growth of general education brought an exchange of healthy scepticism for medieval credulity. The sea serpent, though, continues even today to rear its head in strange sea places and stories of its sighting find occasional notice in the daily newspapers. It is therefore all the more surprising that so few people are aware that the existence of seagoing snakes is a well established fact. They are often caught alive and can be seen in many parts of the ocean in considerable numbers.

But they are not the giant creatures of legend. In fact, the known sea snakes are quite small, a few feet long at most. Is it possible though that, unknown to science, there exists in the sea today a huge relative of the sea snakes which accounts for the persistence of the giant sea serpent legend?

The New England Sea Serpent

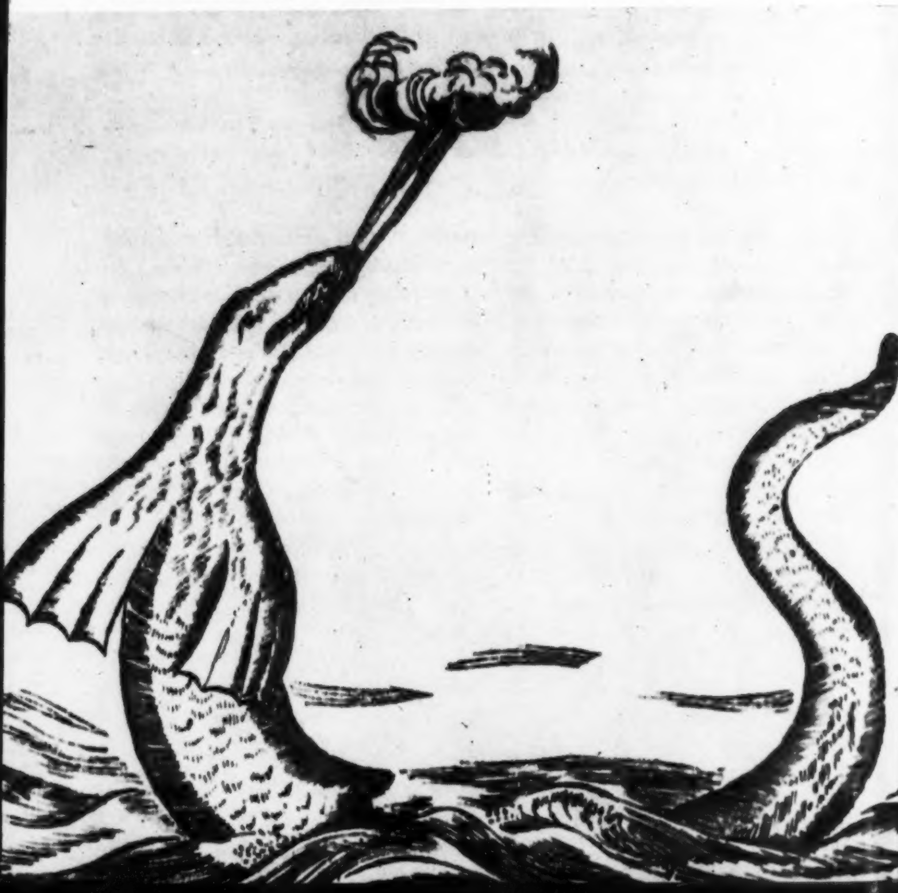
On at least two occasions the giant sea serpent has been diagnosed as a large sea snake. No less a scientific body than the Committee of the Linnean Society of New England gave support to the idea. In June, 1815, a

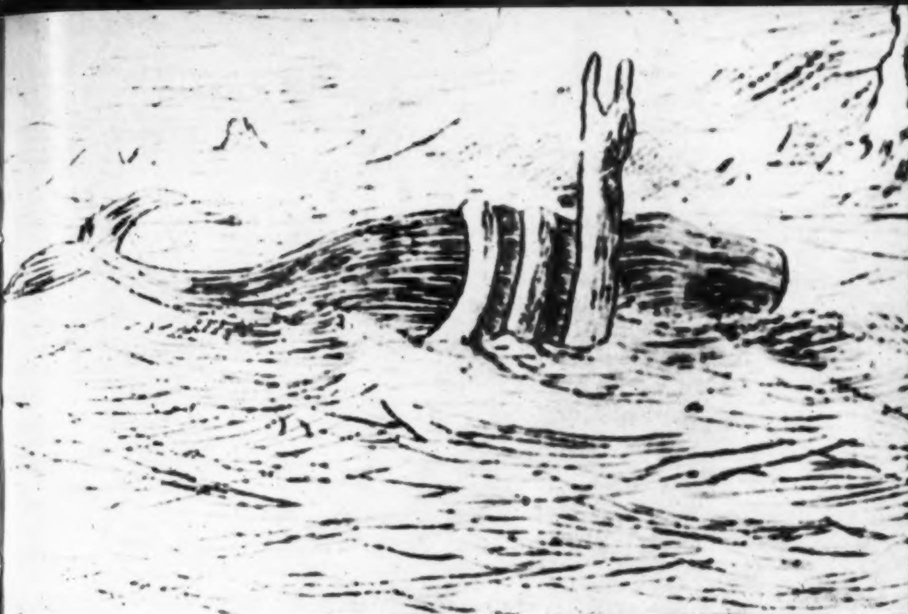
huge sea serpent was seen by Captain Elkanah Finney, in Warrens Cove, near Plymouth. It was between 100 and 120 feet long as seen a quarter of a mile away, with a head 6 or 8 feet long, "looking like a string of buoys." It disappeared within five minutes, but was seen again the next day. Captain Finney, who estimated its speed as between fifteen and twenty miles an hour, was the only person besides his sons who saw the creature. But a few years later, in 1817, the sea serpent reappeared. It was seen by a considerable number of people in the harbor of Gloucester, off Cape Ann, and at Rye Point.

The animal continued to appear on various occasions between August 5 and October 5. One Captain Sewell Toppan, of the schooner *Laura,* was becalmed off Cape Ann when he saw the serpent less than 50 feet away from the ship. Another, Matthew Gaffney, was sufficiently close to fire a gun at the strange monster.

The cautious Bostonians who formed the Committee were careful to

THE SEA SERPENT *as seen by the Dane, Hans Egede, in 1734, and redrawn by a brother missionary from Greenland.*





WHALE ATTACKED *by sea serpent, as seen by crew of the barque* Pauline.

have sworn statements made and placed on record. There was no doubt in their minds that the monster existed and, indeed, the weight of first-hand evidence was formidable. But seeing alone is not fully believing and the capture of an actual specimen became of the utmost importance. It was not long before this desirable event occurred, at least to the satisfaction of the Committee.

A Giant Sea Snake?

The Committee received and examined a small specimen of a snake, found in a field near Loblolly Cove. It was examined by the Committee and pronounced to be identical in all points, except size, with the sea serpent.

The snake was considered to be related to the black snake, *Coluber constrictor,* and was given the name *Scoliophis atlanticus.* It was presumed to be the newly hatched young of the sea serpent, which was supposed to return to land in order to lay eggs.

The existence of the giant sea serpent seemed to be based on good evidence, but to identify it with a small snake killed in a field was going too far. Such a huge monster as that seen in the sea could scarcely support itself on land, let alone travel across fields and lay eggs without even being seen. In any case, those scientifically competent to judge soon diagnosed the little specimen as being a deformed black snake.

The Brazilian Monster

But the possibility that the sea serpent was some kind of sea snake was still admitted and the question again arose when the barque *Pauline* ran into a monster near Cape San

Roque, off the east coast of Brazil, while on a voyage from Liverpool to Zanzibar.

The crew of the *Pauline,* headed by Captain Drevar, subsequently made a signed deposition before the stipendiary magistrate at Liverpool and illustrated accounts of the encounter were published in the *Illustrated London News* of November, 1875. On July 8, 1875, Captain Drevar and some of his officers and crew saw a sperm whale enveloped by two complete coils of a great serpent, with a girth of 8 or 9 feet. The serpent and the whale churned the waters into foam with their struggles for about fifteen minutes and then disappeared. The inference was that the sea serpent dragged the whale beneath the surface.

But this was not the end. The crew, already excited and apprehensive by their experience, saw the serpent again on July 13, and had the amazing experience of seeing it rear itself upright out of water to a distance of 60 feet in the air. ". . . it seemed determined to attack the vessel and the crew and officers armed themselves with axes for self defense." In the dignified scientific journal *Nature,* Mr. Andrew Wilson later published an article in which he concluded, on the basis of the observations of Captain Drevar, Chief Officer Horatio Thompson and other members of the crew, that the monster was a large sea snake, a member of the family Hydrophidae. Wilson, with some justice, remarked that the existence of a large member of the sea snake family was no less likely than the giant squid, since, until a few years earlier, squids were only known as quite small creatures, no larger than the common sea snakes.

Real Sea Snakes

Before examining the possibilities further, let us look at the known sea snakes and judge for ourselves whether they might have evolved a giant relative. Fortunately they are fairly common and in places even abundant, so that there is plenty of information available.

All sea snakes which are definitely known to science, which means that they have been caught and sent to museums for examination and description, belong to a single family, the Hydrophidae. This family is somewhat related to the family of cobras, which includes the coral snakes of North America. So it is not surprising to discover that the sea snakes are all poisonous, some extremely so.

Fifty Kinds of Marine Snakes

One of the best sources of information on sea snakes is a monograph written by Malcolm Arthur Smith, which lists forty-nine species. Clearly there is no doubt that sea snakes exist. But what of their size? Here we meet with disappointment, for the largest is no more than 9 feet long, and most of them do not exceed 3 feet.

Another difficulty in accepting the idea that the monstrous sea serpent is merely a large sea snake is the fact that most of the giant sea serpent reports are from the Atlantic Ocean. But no sea snakes have ever been found in the Atlantic. They are gen-

SEA SNAKE *captured by Ted Bayer, Smithsonian Institute zoologist, while on a collecting expedition in the Pacific Ocean. This particular species is able to live on land as well as in the sea.*

erally confined to the warmer waters of the Indian and Pacific Oceans and the Persian Gulf.

Sea snakes appear to have evolved fairly recently from their land relatives, but they are nevertheless well adapted to their seagoing habits. In fact, they have difficulty in moving about on land. Land snakes have special scales on their bellies which grip the ground and so provide traction for their movement. Sea snakes have lost these scales. They have a tail which, unlike that of ordinary snakes, is flattened and paddlelike, so that it is an aid to swimming. They breathe air but they are able to remain under water for long periods. A rhythmic swallowing and ejection of water seems to provide them with a limited amount of oxygen while submerged.

Born Alive

In still another way these seagoing reptiles are well adapted to their marine existence. The young are hatched from eggs, as in other snakes, but the eggs are retained in the body of the mother until the young are ready to hatch and are thus born alive. The egg has a connection with the mother which serves to convey nutrition to the young. In this way the newborn snake is already well developed and able to begin seeking food immediately.

Shallow waters near shore or the mouths of rivers are the usual haunts of sea snakes, but one species in particular is found as much as a thousand miles from land, from the southeast coast of Africa to the western coast of tropical America.

Snakes By The Million

In some parts of the sea these creatures are amazingly plentiful. One naturalist, Willoughby P. Lowe, describes his experiences off the coast of the Malay Peninsula. From the deck of his vessel he noticed a long line along the surface of the sea. After four hours of steaming, the line, which was about five miles away, began to converge with the ship's course and it was then possible to see that it was composed of a solid mass of orange-red and black sea snakes, thickly twisted together. The line was 10 feet wide and it had been followed for about sixty miles, so that there must have been many millions of individuals.

In the Pacific waters off Panama sea snakes also abound and are something of a tourist attraction. They are particularly common in the Indian Ocean and Bay of Bengal. Specimens of them were collected during the deep-sea expedition of the *Galathea* and caused some alarm on board. They escaped from their aquarium and appeared unexpectedly in the quartermaster's mess late at night, as one of the crew came off duty for coffee. He was naturally somewhat taken aback to see a snake writhing on the deck, on a ship far from land.

Dead By Poison

The venom of sea snakes is very deadly, ten times as toxic as that of the cobra. A small amount is sufficient to kill a dog in less than one hour. Fortunately sea snakes are generally not very aggressive and do not attack human beings unless interfered with. On the other hand,

there are records of fishermen who have died as result of being bitten by a sea snake when removing it from the net.

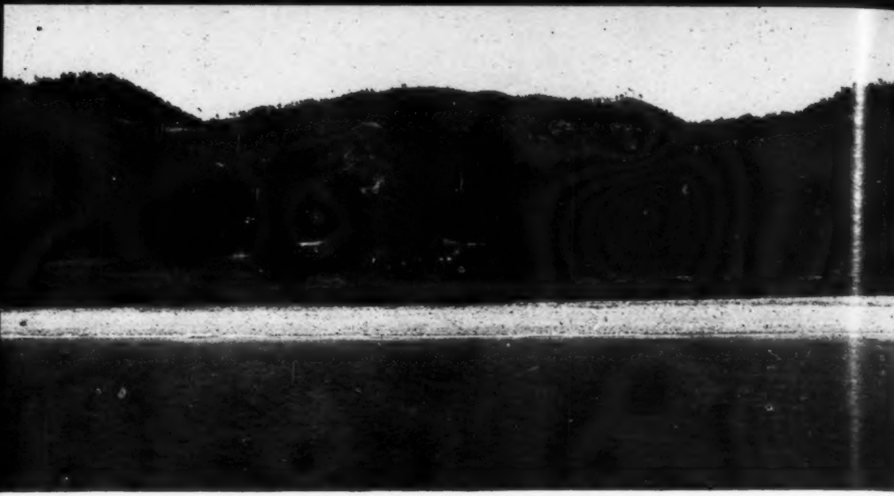
The poisonous nature of these creatures has obvious advantages, since they feed entirely upon fish. Because of the spines in the fins, it would be difficult to swallow an active living fish. When bitten and poisoned by the snake, the spines of the fish relax and it is swallowed head first. The spines are not easily digested and, because of their size and sharpness, their passage through the digestive tract would seem to present a problem. It has been reported that in some of the snakes the fish spines pass through the walls of the intestine and body wall to the exterior, without, apparently, causing any inconvenience. The sea snakes with small heads and slender forebodies are not concerned with this difficulty since they feed almost exclusively upon eels.

Used For Sausage Meat

The romantic and mysterious aspect of the monster sea serpent is exploded by one of the uses to which the true sea snakes are put. Malcolm Smith saw sea snakes on sale in the fish market in Hainan, where they were chopped up and made into sausage meat. They have also been used as food in Tahiti.

The absence of sea snakes from the Atlantic, where the monster sea serpent has most often been reported, the small size of sea snakes, and the fact that flippers or paddles have been described so often in sea serpent accounts, together weaken the probability that the serpent is a giant sea snake. All of the sea snakes, with one exception, live near the shore. Only *Pelamis* has become adapted to life far from land. Others feed on bottom fish on reefs or along the shore. *Pelamis* feeds on surface fish and has been able to migrate across the Indian and Pacific Oceans, from Cape Town to Panama. Is it possible that this brightly colored snake, with black back and yellow underbody is related to a giant sea serpent?

The answer will not be known for sure until the sea serpent, if it really exists, is caught and examined. The people of Plymouth and Gloucester, independently and in considerable numbers, agreed that they saw it and were willing to sign statements to that effect. But it must be remembered that only two centuries previously the people of this state were convinced that they had seen evidence of witchcraft. And the Committee of the Linnean Society of New England was obviously in a mood to favor the sea serpent's existence when it so readily accepted in its place a little deformed black snake.



VIEW OF *Laboratory from the Euboean Sea.*

A Greek Marine Station

By ANAST. A. CHRISTOMANOS

The Marine Biochemistry Laboratory, St. George, Limni

SOME OF THE EARLIEST biological observations were made by Aristotle and it is interesting to consider to what extent modern Greece is carrying on the ancient traditions of interest in the sea and philosophical enquiry. One of the latest additions to the list of scientific institutions provides a partial answer.

On the Island of Euboea

Three years ago, near the small town of Limni on the Euboean Island off the central part of Greece, a new laboratory was established for biochemical investigations of marine life. The buildings of this new institute lie in a typical Grecian setting near the foothills of Mount Kandyli, which climbs to 3,300 feet and drops from this height abruptly into the sea.

The Euboean Sea, between the island and the mainland, is narrow, an average of six miles across in the northern part, but is nevertheless 250 fathoms deep and is subject both to large tidal movement and, in the winter, to severe storms.

The sea near the Institute has an ample supply of marine life on its partly sandy, partly rocky bottom. There are many sea anemones, holothurians and sea cucumbers and yellow sponges of non-commercial varieties. A variety of species of fish move among the rocks and, during the winter, schools of tunas and swordfishes migrate into the waters. Sharks, however, are seldom found.

Buildings and Equipment

The laboratory occupies two large

buildings equipped principally for biochemical research and a museum of the seashells, shellfish and sponges of the Mediterranean. For visitors and scientific workers there are living quarters and laboratory space. So far the equipment and apparatus acquired represents a fraction only of what is necessary and the library is particularly in need of important journals and reference material.

Most of the funds for the establishment of the Institute came from the Greek Chemical Industries, the University of Athens, and from private sources. In its administration, the Laboratory is independent, but is operated in close cooperation with the University. Although the greater part of the work is at present biochemical in nature, it is hoped to extend it, in the future, over a broader field of oceanography. In Greece generally, the development of a laboratory such as this is greatly handicapped by the lack of books and periodicals and it is hoped that institutions in the United States and elsewhere possessing duplicates or reprints will give us what assistance is possible.

What's in a color?

Apart from organization and the development of a museum which is unique in Greece, our principal attention has been given to some of the fascinating problems concerning the nature of the pigments or coloring matter of some of the fishes and lower organisms.

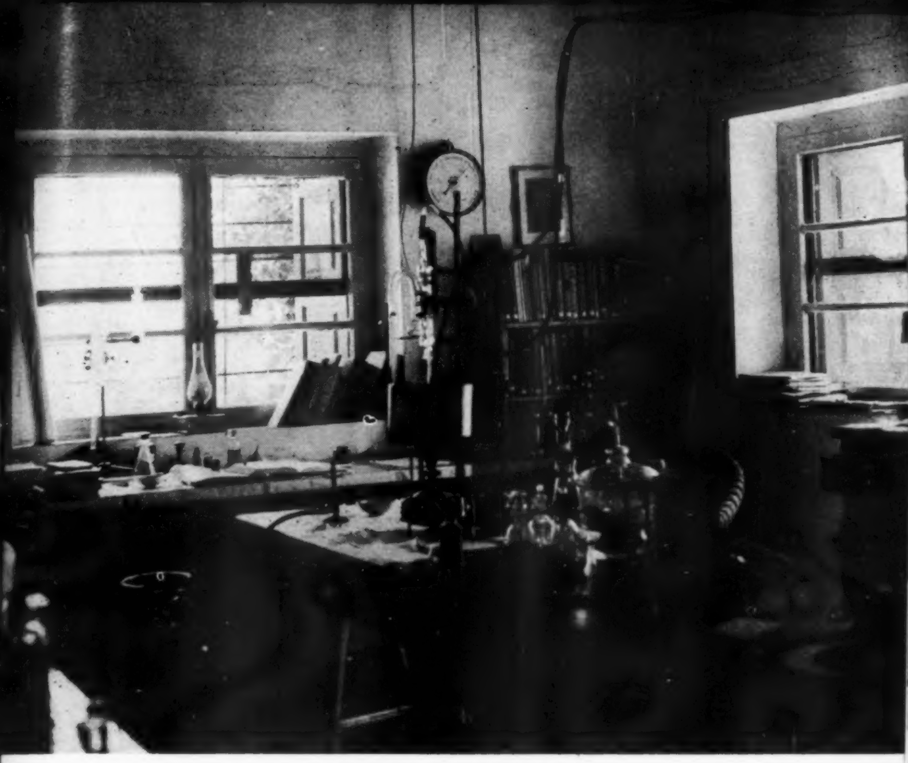
The colors or pigments of animals and plants are not simply matters of beauty to the scientists. Many of them

MAP SHOWS *location of laboratory on Euboean Sea.*

are of vital importance to the chemistry of the body as, for instance, the haemoglobin of red blood which carries oxygen to the tissues. In our laboratory we have studied a number of other interesting pigments. One of these is the violet colored "ink" which is exuded by the Mediterranean sea-slug, *Aplysia depilans,* when it is disturbed. Until now there has been little agreement as to the chemical nature of this. We have now found that it is actually a mixture of at least three different pigments, a red, a blue and a green one. They give off a reddish brown fluorescence in ultra violet light, unlike the related bile colors or bilichromes.

In one of the sea anemones, *Adamsia,* there is a red pigment in the stinging threads. This we have found to be a protein color or chromoprotein. It has the peculiar property of changing from red to yellow when dried. In moist air its red color is restored. It is one of the colors known as carotenoids, which are frequently found

SPIDER CRABS *on the top shelf of the laboratory museum. Branching plant-like gorgonians, marine creatures related to the corals, sea anemones and jellyfish are on the other shelves. Among other sea creatures of the Mediterranean are the sponges from which the bath sponge has for centuries been derived.*



CORNER *of the biochemical laboratory.*

in plants and in animal fats. They are related to compounds which include vitamin A. Another carotenoid is found in the Mediterranean jelly fish, *Rhizostoma pulmo,* to which it gives a violet color.

Pigments in fish scales

The needlefish, *Belone belone,* has a green pigment in its scales which has been separated by chromatographic techniques into four different colors, ranging from green to yellow. These are very closely related to the green color found in bile, bileverdin.

The yellow sponge of the Euboean Sea, *Aplysina aerophoba,* contains a yellow-green pigment which is very sensitive to oxygen, so that when exposed to air it changes into a dark colored substance. Research upon this is still being continued. It is hoped that the future may bring many new and interesting discoveries about the colors of the Mediterranean sea life, as a result of the investigations of this new laboratory.

PART OF THE FLEET *of salmon fishing boats seen from a distance.*

Saga of the Sockeye

By JACK D. REMINGTON

International Pacific Salmon Fisheries Commission

EACH YEAR in early summer, silver legions of sockeye salmon migrate landward from the sea. A mysterious chain of events causes them to leave their North Pacific feeding grounds and turn toward fresh water. The firm, red flesh of their powerful bodies is full of oil—their fuel-in-storage for the long journey to inland spawning grounds. They cease feeding as they near the mouths of their home rivers, and their digestive systems miraculously wither and become useless. At the same time the eggs and sperms are growing, filling their body cavities with the next generation.

Sockeye migrating toward British Columbia's Fraser River travel as if on a compass course southward along the west coast of Vancouver Island. A few are caught by troll fishermen before they reach Juan de Fuca Strait, a narrow strip of water separating Canada and the United States. After they enter the Strait, and before they reach protected waters, fifty miles above the mouth of the Fraser, they must run a gauntlet of purse seines, gill nets and reef nets waiting on both sides of the international border.

A Check On Over-Fishing

So intense is the fishery that almost all of the sockeye could be captured if there were no regulations. Recommendations for such rules are a responsibility of the International Pacific Salmon Fisheries Commission, formed by a Canada-United States

convention and ratified in 1937 for ". . . the protection, preservation, and extension of the sockeye salmon fisheries in the Fraser River system."

Sockeye navigating Juan de Fuca Strait are destined for widely-separated spawning grounds, and they go through the fishery in distinct groups at different times. Closures of the fishery are aimed first at allowing about twenty per cent of each major group, or "race," to escape to the spawning grounds, insuring reproduction. The Commission must also divide the catch equally between Canadian and American fishermen. This provision of the convention has been carried out with remarkable precision, even though the catch in recent years has varied between two million and ten million sockeye.

Sockeye "Identification Cards"

Present management of the sockeye fishery is based on the fact that there are distinct groups of fish, bound for separate spawning areas. But how may one race of sockeye be distinguished from another? Sockeye salmon carry their "identification cards" in their scales. As they enter the fishery, scale samples are taken from hundreds of fresh-caught fish each day, and are "read" in the laboratory within a few hours. Examination of the central portions of the scales reveals exactly which lake each fish was reared in during its freshwater life. Using this method, Commission scientists can tell which spawning areas the adult fish are bound for, even before they leave saltwater.

Sockeye salmon are among the most desirable of food fishes. The rich flavor and nutritional value of the flesh is proof of the vast food resources of the North Pacific Ocean. In years gone by, salmon were so important to the Indian tribes along

GILL NETTING FOR SALMON *is carried out on this type of one man boat. The drum in the stem is used in operating the nets in this very efficient type of fishing operation.*

the Pacific Coast of North America that they were held in veneration, and elaborate rituals and ceremonies were performed upon the arrival in the stream of the first salmon.

Corruption of "Suk-Kegh"

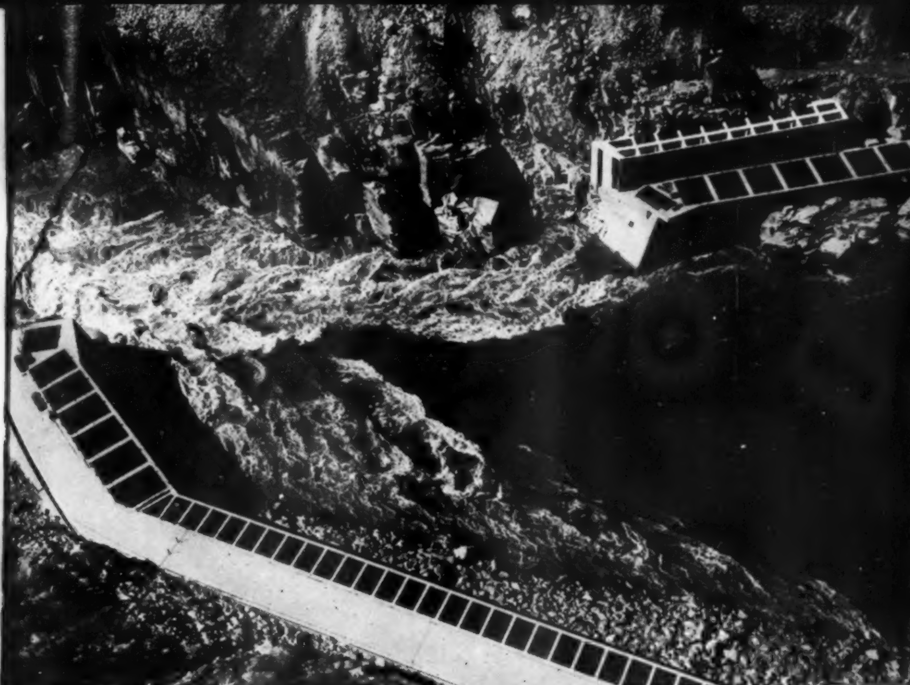
The common name sockeye is a corruption of the Coast Salish word "Suk-kegh." Sockeye runs meant the difference between life and death for some of the inland tribes. Hudson's Bay Company records of 130 years ago reveal that in the British Columbia interior, sockeye salmon was the staple food of the Indians. The fish were eaten fresh during the short migrating season, and dried for use during the rest of the year.

When the sockeye runs failed (which seemed to be the case in at least one year out of four), the Indians starved. This historic fishery is still supplying food to some of the Indians, but it is becoming less important as more and more of them adopt modern ways of stocking the larder.

An Assist Through "Hell's Gate"

Sockeye that are allowed to elude the nets of the commercial fishermen and the primitive gear of the Indians continue their journey, headlong up

SALMON SCALE *enlarged to show growth rings. The Fraser River sockeye salmon from which the scale was taken was four years old. The close spaced rings in the center indicate the period of freshwater growth and give a clue to the origin of this particular fish.*



HELL'S GATE. *Railroad construction in the Fraser Canyon in 1913 resulted in a large rock slide at Hell's Gate, which obstructed the passage of sockeye. These fishways, constructed in 1946 at a cost of approximately* $1,000,000, *have remedied depletion of the sockeye runs caused by the slide. Rehabilitation of the sockeye runs since 1947 has increased the catch to* 18,000,000 *sockeye in the brood-cycle period 1951 to 1954 from* 6,500,000 *sockeye in the previous period 1947 to 1950. The value of the increase in the pack for the last four years is* $42,200,000.

the murky waters of the Fraser. The test of strength begins as they climb steadily against the strong current, passing through the coastal mountains in a narrow, turbulent gorge. One hundred thirty miles from saltwater, at a place called Hell's Gate, they are assisted through the narrowest part of the canyon by man-made fishways. Near the highway that follows the river above Hell's Gate, a stone historical monument marks the spot. Beneath crossed Canadian and American flags on a bronze tablet is the following legend:

"Six hundred feet below this point the Fraser River flows through the constricted canyon known as Hell's Gate. From 1913 to 1945 the valuable runs of sockeye salmon en route to their spawning areas above were periodically delayed or blocked by the effects of slide rock. Here the International Pacific Salmon Fisheries Commission has built concrete and steel fishways of unique design. These fishways now enable the sockeye salmon to pass freely through the turbulent area thus permitting the

THIS HISTORICAL MARKER *at Hell's Gate commemorates international cooperation in the rehabilitation of a valuable natural resource.*

restoration of a multi-million dollar fishery."

After a two-day swim from Hell's Gate (at the sockeye rate of seventeen to thirty-three miles a day), some of the fish turn from the turbid Fraser to the blue-green water of its largest tributary, the Thompson River. They continue to the Shuswap Lake area, home of the famous Adams River run.

Return To Scene of Their Birth

No one has completely explained what compels a salmon to migrate, and no one knows exactly how the fish are guided, but it has been proven that mature sockeye return to the gravel in which they were born. The fish that made the incredible runs up the Fraser, the South Thompson, Little River and the Adams River in 1954 were the offspring of fish that made the same three hundred mile journey in 1950. They came ten million strong from the ocean, leaving eight million of their kind in American and Canadian canneries. More than one and one-half million of them crowded onto 150 acres of gravel in the Adams River, which drains Adams Lake, runs seven turbulent miles, and pours into Shuswap Lake near the outlet. In nearby Little River, outlet of Shuswap Lake, almost a half-million sockeye spawned in about one and one-half miles of stream.

Spawning In Shifts

The entire spawning population is not on the spawning ground at one time. The run is spread out over about a month, with some fish arriving early, the majority forming a "rush hour" and some being latecomers. The timing of the individual parts of the run is adhered to closely during the entire migration and spawning periods. For instance, the 1954 Adams River fish were spotted in the commercial catches during the first part of August, and some were still being caught in early September. First arrivals on the spawning grounds in Adams River were seen during the last few days of September. The peak of spawning occurred between October 10th and 20th, and some fish were still spawning during the last few days of October.

Some sockeye are produced in small, feeder streams (as far as seven hundred miles from salt water), and a few are spawned in lakes with bottom seepage, but the majority of Fraser sockeyes come from lake outlet spawning grounds, such as the Adams River. Here is the environment favorable for incubation of eggs in gravel. A constant stream of water carries oxygen to the eggs, and waste products away. The water is tempered by the vast amount of heat stored in the lake depths during the summer. Thus eggs deposited in the gravel rather late in the fall can still develop

Males Are Show-Offs

As the adult fish near their spawning grounds, they go through some remarkable changes. Before sockeye enter fresh water, it is difficult to distinguish males from females by external appearances. But as they get to the end of the journey, it is easy

DIP NET FISHING *for sockeye salmon. This method of fishing has been used on the Fraser River and its tributaries by countless generations of Indians.*

Spawning salmon. *Sockeyes engaged in spawning in the crystal clear waters of a mountain stream. All of these fish will die shortly after they have completed spawning.*

to tell them apart. The males are the show-offs, and like their counterparts in the bird-world, they exhibit striking colors during mating. Their sides become an unbelievably brilliant red and their heads turn to a pea green. The snouts of the males become quite long and hooked, and their mouths are suddenly full of vicious-looking teeth.

The females don't grow a hooked snout, but they do lengthen and sharpen their teeth. Anyone familiar with sockeye as they are in the ocean would swear they are not the same fish on the spawning beds. Most of the returning sockeye are four years old (from the time they were deposited as eggs). Some precocious fish, usually males, return as three-year-old "jacks", and some wait until they are five years old (rarely more) before spawning. The jacks average nineteen inches in length and about three pounds in weight, while the four-year-olds are about twenty-four inches and six pounds. The five-year-old fish are about twenty-six inches and seven and one-half pounds on the average. Unusual sockeye (probably more than five years old) have weighed over fifteen pounds, and have stretched to thirty-three inches in length.

Internal changes also are going on as sockeye approach their home stream, but these changes are not so easily observed. Both sexes become just carriers for the developing sex products. The females retain the typical ocean-salmon shape, except for their swollen bellies. As she reaches the spawning grounds, and providing water temperatures and water levels are satisfactory, each female selects

CLOSE UP VIEW *of spawning sockeye salmon. They carry out their task unmindful of the dead bodies of their comrades in the foreground.*

a home territory in the gravel. Typical gravel may contain particles ranging in size from fine sand to stones four inches in diameter.

Female Excavates A "Redd"

The nest-site most often is at the tail end of a pool, just above where it breaks off into the next riffle. Water depths are not great, and water velocities usually are moderate. At times they spawn where their dorsal fins are out of water. The female excavates her "redd" by lying on her side and flapping her tail vigorously. This action kicks up the gravel, and the current carries the smaller particles downstream.

The process is a slow one, and as she labors, the male that has picked her for a mate continues to fight off other males that are unattached. For this infighting the long teeth are especially useful. With them they grab tails, shake vigorously, and hang on like bulldogs. Occasionally while the female is resting from digging the redd, the dominant male will swim above and around her, sometimes nudging her in courtship.

Free Lunch For Bears

The commotion that results when hundreds or thousands of salmon are on a spawning ground attracts a lot of attention, especially from bears. Bears love to eat salmon, alive or dead, and they congregate near the streams when the salmon run is on. Bears will settle for a spawned-out fish when nothing else is obtainable. There can be no doubt that the fatness derived from gorging themselves with salmon helps to carry bears through their long winter sleep.

Biologists *examine dead sockeyes and record information. From this data it is possible to determine how successful the year's production has been. Information of this kind is gathered each year from all of the major Fraser River spawning areas.*

Seals also have a fondness for salmon, and are not content to let the fish leave the ocean. They follow and harass the silver schools in fresh water, sometimes as far as spawning-grounds relatively close to the ocean.

When the female is satisfied that her redd is the right depth and size she lowers into it, the male close by her side, and deposits a portion of her orange-pink eggs in the bottom. At the same instant the male fertilizes the eggs with a cloud of sperm, and a new generation is started. The digging, courtship, fighting, and egg-laying are done over and over, each time upstream from the preceding nest. The gravel is thus carried downstream, covering the eggs to a depth of four to sixteen inches.

End of The Drama

When the female has deposited all of her eggs (the number could vary from three thousand and five thousand) she stays near the final redd for some time, digging half-heartedly now and then. The male senses that she is through and leaves the scene, usually dropping downstream to a quiet stretch of water where he wastes away slowly.

By the time spawning is completed both the male and female have started to deteriorate from the outside in. Large gray blotches appear where the blackened skin is dying. Fungus starts its clean-up work even before the fish have ceased holding their own against the current. The tails of the females have been worn to stubs from digging in the gravel.

Even as the fish die and quietly drift along the bottom, others are still busy with their final spawning acts. They all die after spawning, and this is not surprising. From fat, energy-

filled ocean fish they have been reduced to nothing more than skin and bones. Between the ocean and the fresh-dead condition following spawning, they actually lose two-thirds of their dry weight.

Orphans of The Gravel Beds

Under the gravel the eggs are protected from light and also from Dolly Vardens, rainbow trout, and other egg-eating predators. These opportunists lie in wait below spawning sockeye to fill their bellies with the waste eggs that drift down in the current The covered eggs start developing immediately after fertilization, and in about eight weeks they reach the "eyed" stage when the large eyes can easily be seen through the outer covering. The alevins hatch out of the eggs while they are still in the gravel, and live on material from their attached yolk sacs. They are all orphans; they never see their parents, and will never see their own offspring.

By the time the water begins to warm up in the spring the stored food has been used, and the fry wriggle up to the surface of the gravel and emerge under cover of darkness. They are swept downstream by the current, and when quiet water is reached, they begin travelling in schools.

Nature's Unexplained Forces

Sockeye are born where they have access to a lake. If not in a lake itself, the spawning grounds usually are immediately above or below one. It is a simple procedure for the fry from lake-inlet spawning areas to reach the lake. They just ride the current to get where they're going. It is a different matter and an amazing reversal of behavior for fry that emerge from the gravel in a lake outlet. They must feed in the slow-moving stream shallows until they are strong enough to buck the current and ascend into the lake. Here the fry feed heavily on minute crustaceans and other tiny

POSITIVE ACTION *towards rehabilitation of barren streams is taken by "planting" salmon eggs in the gravel. The eggs were borrowed from salmon in another stream, fertilized, and held until they reached the "eyed" stage. At this stage they are taken to a suitable locality in the barren stream.*

SAFE FROM WINTER'S CLUTCHES, *millions of sockeye embryos are developing in their beds of gravel. This flowing stream is almost completely frozen over by the prevailing zero weather.*

water animals and grow quickly in their lake "rearing ponds," remaining through at least one winter in the lake.

The following spring, sometimes even before the ice is gone from the lake, they respond to another of Nature's unexplained forces, and, as a group of three-inch "smolts", most of them leave the lake. A few of them remain an extra year, and leave when they are four to five inches long. They reverse the route taken by their parents—down the headwater streams, down the murky Fraser River — to disappear in the broad reaches of the Pacific Ocean. When they have grown to maturity, and those mysterious urges again are felt, they return as their parents did before them, to complete another chapter in the never-ending cycle of life.

Unexploited Waters

By DEREK MILLS

Fisheries Research Board of Canada, Ottawa

"THAR SHE BLOWS!" A cry usually emitted by the whalers on sighting their quarry in the cold, plankton-rich waters of the Antarctic during the summer whaling season. But this time the exclamation rang out from the boat deck of our trawler, the *Cape St. Mary,* as she steamed off the southern coast of Sierra Leone. A school of humpback whales had been sighted swimming south, blowing regularly and exposing their curved flanks to the tropic sun.

The sighting of these whales had been but one of many incidents while trawling off the coast of French Guinea and Sierra Leone where the sea is rich in marine life. Not only had our trawl brought up quantities of edible fish from the sea bed in the form of snappers, croakers, threadfins, sea bream and sea perch, but our trolling lines had pulled out of the surface waters many small tunny, large mackerel and the classic Dolphin fish.

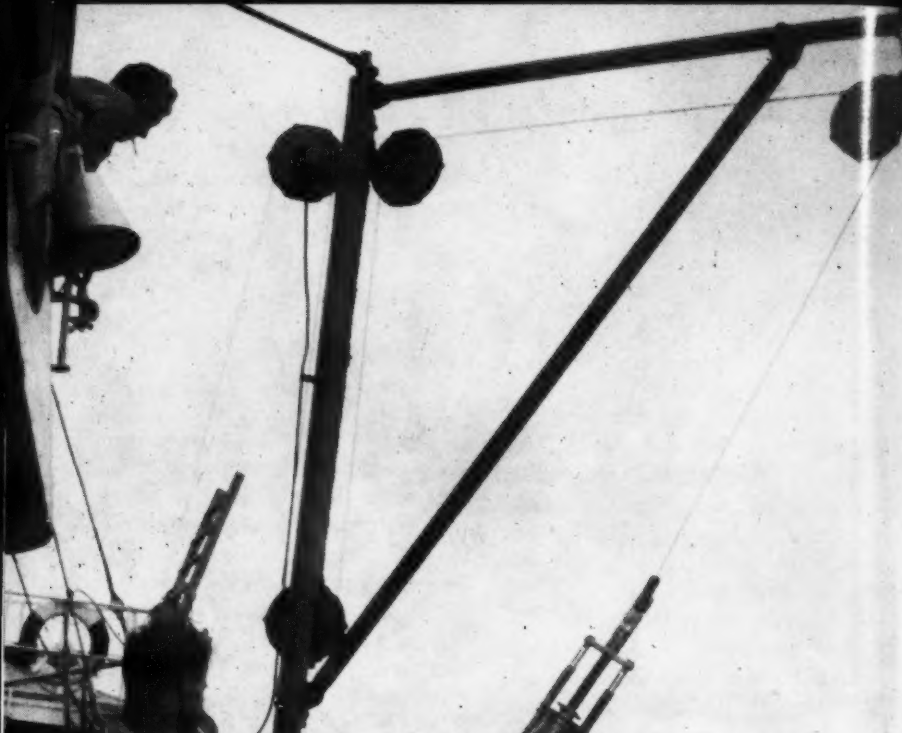
Due to the Canary, Guinea and Benguela currents there is a great deal of upwelling off the West African coast and the deeper layers of water rich in nutrient salts are brought to the surface. This causes outbursts of plankton which afford a food supply for a greater fish population than exists in many other parts of the tropics.

The Continental Shelf, on which nearly all the rich fishing grounds of the world are situated, is nowhere very wide around West Africa, but in the waters over the wider portions of the shelf, especially from Sierra Leone to French Guinea, the fishing is found to be good.

Protein Deficient Diet

Since the 1920's British West Africa has opened up and the population has consequently increased. With an increase in the population a greater demand has been made on the available food supply which in itself is limited. Cattle are scarce due to the Tsetse fly belts and the amount of land suitable for cultivation is relatively small. It had long been realized that there was a deficiency of animal protein in the diet of the natives in the colonies and although it could have been introduced in no more

Two *African Horse Mackerel* (Caranx africanus), *caught on trolling lines during a survey of the offshore waters of Sierra Leone.*



A WATER SAMPLING *bottle is brought inboard after collecting a sample of water. When the temperature of the water has been read from the thermometer housed in the mechanism, the sample will be transferred to a glass bottle for determination of the oxygen and salinity content. Photograph taken during a hydrographic cruise of the* F.R.V. Cape St. Mary.

beneficial or palatable way than by the consumption of fish, the rich fishing grounds off Gambia, Sierra Leone, the Gold Coast and Nigeria, were never fully or reasonably exploited.

As far back as 1928 James Hornell carried out a survey of the fisheries resources of Sierra Leone. He reported that they were so great that enormous development was possible, such fishing as already existed being on so small a scale as to be relatively insignificant.

Unsuccessful Attempts

Two attempts actually had been made to establish a fishery in Freetown, Sierra Leone. In 1912 a trawler averaged a catch of a few tons a day for some months but lack of organization for the marketing resulted in failure. In 1928 a further venture failed as the trawler employed was not suitable for operating in deeper waters.

During the Second World War a large number of troops were garrisoned throughout West Africa. This threw too great a demand on the local food resources and with a limited external food supply it therefore became imperative to augment the colonies' food supplies from hitherto untapped or inadequately utilized resources.

An examination of the potentialities of the already existing local fisheries in Sierra Leone was made by Dr. G. A. Steven. This investigation clearly revealed that there was little possibility of the native fishing methods being able to produce any significant and stable increase in the fish production as the five principal modes of fishing combined yielded under 5,000 tons of fish annually. But due to the untiring work of Dr. Steven the annual catch did rise to 6,000 tons in two years and efforts had also been made to can fish.

In 1942 the Navy stationed in Sierra Leone was asked by the local government to assist in landing more fish if supplied with the necessary gear. The intention was that all fish caught were to be divided between the services and civilian population. Unfortunately due to a change in the operational situation at sea the Navy was unable to give much assistance, although in 1943 H.M.T. *Syringa* caught 1,700 pounds of fish for three hours' fishing which showed that good results might have been obtained had the Navy been able to give more help.

No further trawling was carried out until 1945 when the trawler *Maid Honor* made some preliminary trips which were quite successful. However, quite a few setbacks were met with. One in particular was the scarcity and exhorbitant price of ice. Ice was most essential as fish caught in the early part of the day would not keep unless iced down. Another snag was the fact that the African crew had had little training in handling and repairing trawling gear and this resulted in a loss of fishing time. A marked characteristic of the fishery which became manifest during these trips was the unpredictable movements of the fish themselves.

Necessity for Oceanographic Research

So one thing which came out of this last venture was the realization that if an efficient fishing industry

was to be set up a long term research plan would be necessary. Investigations could then be carried out on the life histories, growth rates and migrations of the food fishes and their predators, the hydrography of the area and plankton production so that in due course it might be possible to predict good and bad fishing seasons.

It was therefore necessary to establish a Fishery Research Station to undertake these investigations into the general problems of marine biology and oceanography common to the whole West African region.

In 1950 Dr. Hickling, Fisheries Adviser to the Secretary of State for the Colonies, went to Freetown and selected a site for the laboratory. In July, 1951, the research vessel *Cape St. Mary,* built for the newly-formed West African Fisheries Research Institute, arrived in Freetown.

Game Fish

This well-equipped research vessel has since been carrying out trawling, plankton and hydrographic surveys from the Gambia to the Cameroons. Problems of ice supply have been satisfactorily solved. All fish caught are stored in the fish room and this is supplied with ice by a refrigeration plant on board. On reaching port the fish are sold to local buyers.

During some of the surveys trolling lines have been towed astern to obtain some idea of the distribution of the pelagic fish. Besides several species of mackerel and the dolphin, two species of tuna have been recorded—*Parathunus obsesus* and *Euthynnus alleteratus.*

In the estuaries large tarpon abound and they have been known to do extensive damage to the nets of the native fishermen.

The Future

In one respect, at least, the situation here is almost unique. Usually, research is not undertaken until a fishery has long been established and in some of the problems, at least, it is like locking the stable door after the horse is gone. But fishery research in West Africa has preceded a fishing industry which is still in its embryo stage. This ideal state of affairs means that it will be possible, due to the investigations being carried out, to give the industry guidance throughout all stages of its life and afford it chances of immortality by not allowing the problem of overfishing to arise.

Hellenic Oceanographic Society

GREECE has joined the growing family of nations that have an Oceanographic Society. In January 1957 a group of scientists and others interested in oceanography established the National Hellenic Oceanographic Society. According to an announcement from Dr. Anast. A. Christomanos, president, membership is open to all interested in oceanography, including marine biochemistry, biology and marine geology.

ELECTRIC LIGHTING *provided by an eel. Christopher Coates, director of the New York Aquarium, stimulates an electric eel, which gives off sufficient electricity to light the lamp at the left in the picture. Note that Mr. Coates wears rubber gloves. The electric shock given by this eel can be quite severe.*

Living Power Plants

By CHARLES E. LANE

The Marine Laboratory, University of Miami

IT HAS often been noted that, in one form or another, many of man's engineering accomplishments have been anticipated by nature. We have merely developed sufficient understanding of them to be able to adapt them to our own uses. For example, we depend heavily upon electricity during almost all of our waking and sleeping moments. This has only been so for a few years, less than a century. And yet, for millions of years, certain fishes have produced their own electricity and have used it both for obtaining food and for defensive measures.

All Animals Generate Electricity

The fact that half a dozen different kinds of fishes and eels can generate electricity, some of them in quantities sufficient to stun a horse, is of interest in itself, but the electrical generation of shocks is only one special instance of a very general condition in nature. In fact, the ability to produce electricity is not unusual. It actually exists in all living creatures. Every time a muscle con-

tracts, maybe the mere flick of an eyelid, or when a nervous stimulus reaches or leaves the brain, electrical impulses also occur, although of very low intensity.

The electrical properties of living tissues were first described by Galvani in 1791. Since that time the relationship between various kinds of animal activity and electricity has been studied in a wide variety of animals. In 1843 Du Bois Reymond discovered that a galvanometer or electrical meter, when connected by wires to the surface of a muscle and to its cut end, showed the passage of electricity. The modern physician makes use of the weak electrical currents generated by the beating heart. When they are recorded on a diagnostic "electrocardiogram," they reveal the way in which various portions of the heart muscle are working. The action of the human brain, in a similar way, reveals itself by electrical peaks which are recorded in the electroencephalogram. Contraction of muscles, movements of impulses along nerve fibers and secretion by gland cells such as digestive or salivary glands, all of these cause changes in electrical potential. Indeed, it seems likely that all biological activity may be accompanied by electrical changes which may be detected by measuring instruments of sufficient sensitivity.

Electric Eels, Catfishes, Rays

What is the relation between this universal generation of small electrical potentials in living things and the rare ability of certain fishes to give severe shocks? The fresh water electric eel, *Electrophorus electricus*, the electric catfish, *Malapterurus*, the marine electric ray, *Torpedo*, and a number of other less well-known species, have all evolved the ability to produce rather formidable electric discharges. In every case the ability to shock is used against other animals for purposes of food-getting and of protection. There is also some recent evidence which suggests that rapid rhythmic discharges from the electric organ may assist in navigation of the fish, just as a bat uses sound pulses and echoes for avoiding objects during flight.

Living Electric Generators

The electric fishes have special organs for producing their electric power. In some species the electricity is quite weak, but in others it is sufficiently powerful to disable an adult man. The maximum current varies, of course, from species to species but it also varies from one part of an electric organ to another in a single animal. In an average specimen of the electric eel, about three feet in length, the current produced is about 1 ampere at the front end of the organ. Values of about 4 amperes have been found in an electric ray, *Narcine brasiliensis*. This is a current comparable to a household lighting circuit. But a value of 120 amperes was roughly estimated for a very large specimen of the torpedo ray, *Torpedo occidentalis*. How is this powerful force generated? Let us look into the structure of one of the organs.

Electric organs vary widely among the different species in their shape and size and in their position and

ELECTRIC RAY, *dissected in order to show its electric organ. The head is to the right and tail to the left. When the skin is removed from the surface at the head end the electric organ is exposed. On the right side of the body (bottom in the picture) can be seen the kidney shaped organ. On the left side (top of picture) the organ is dissected further to show the nerves which serve it.*

arrangement in the body of the fish. All, however, are made up of sets of similar basic units, which are known as the electroplates, much as a battery is built out of cells. The units are minute disc-like structures, each of which is a single living cell, containing several nuclei. In this respect they are similar to the cells of voluntary muscle fibers. Each has a nerve connected with one surface but not with the other. The battery of electroplates all face in the same direction, in a manner similar to an arrangement of dry cells or storage batteries in series.

The most regular and symmetrical arrangement is found in the electric ray, *Torpedo*. In this fish, the plates are piled in columns with an average of about 400 plates to each column. Each column extends from the lower surface to the upper surface of the body. One might compare a column to a stack of pennies. Four or five hundred such columns, packed side by side, go to make each of the pair of electric organs. These organs are large enough to form the main mass of the disc-like body of the fish, on each side of the body cavity.

LEFT HALF *of an electric ray dissected to show the structure of the electric organ, which has the superficial appearance of a mass of eggs. Actually, each circle is the upper end of a pile of discs, the electroplates, each of which produces its individual small electric discharge. By stacking the discs in piles, the charge is greatly magnified.*

When the electricity is discharged, the current in each organ passes from the lower to the upper surface. Electricians will see that, with this arrangement, the columns are connected in parallel and determine the amperage, while within each column the electroplates discharge in series, thus determining the voltage. The general arrangement of the electric organ of *Torpedo* is clearly seen when it is dissected out in the laboratory. The photograph shows an actual dissection performed by the famous eighteenth century English anatomist, John Hunter, and still preserved in the Hunterian Museum of the Royal College of Surgeons.

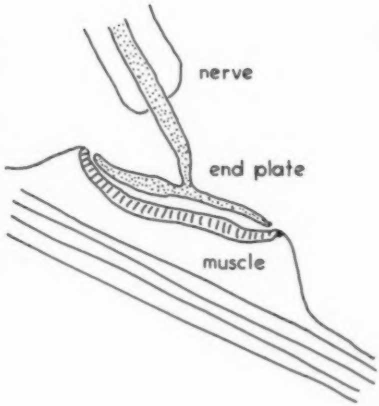
High Voltage Eels

In the electric eels, the electric organ is somewhat different. It is greatly elongated and may take up one half of the entire fish. The columns of electroplates run parallel to each other from head to tail of the fish, so that, again comparing with the storage battery, the voltage is increased but the amperage reduced.

Studies of the early growth of the electric organ have shown that it is really nothing but the ordinary voluntary muscle of the fish which has become highly specialized and modified. It can be said, in fact, that this is simply a muscle which has lost its ability to contract, but in which the electrical generating abilities found in all muscles are enormously increased.

Voluntary muscles generally contract in nature only when they have

been stimulated by the passage of an impulse from a nerve to the substance of the muscle itself. These impulses normally enter the muscle fiber at specialized places known as motor end plates, electrical terminals as it were. The illustrations show the electric organ, resembling a stack of coins on edge. It can be seen that each of the coins, or electroplates in the column bears certain resemblances to the motor end plate or nerve terminal of normal voluntary muscle. It is therefore easy to understand why the discharge of the electric organ in fishes is always under the control of the nervous system of the animal—just like the muscle it was derived from.



NERVES JOIN MUSCLES *as shown in the cross section diagram above. The nerve terminates in an endplate which is closely applied to the muscle, like an electrical terminal. The units or electroplates of electric organs in fishes are similar to the end plates and are stacked one above the other like a pile of coins.*

Like Huge Banks of Batteries

Because of its specialized structure one might expect to find that the electric organ worked in a very different way from the ordinary kind of muscle. But, on the contrary, extensive investigations of muscles and nerves in a wide series of animals have revealed that the voltage obtainable from a single electroplate is somewhat the same as the voltage of a nerve impulse or that of a contracting muscle. In both muscle and nerve the resting membrane potential is about 50 millivolts.

Since the fibers or cells in a muscle are generally arranged side by side, in parallel, the voltage from a large muscle containing many thousands of fibers can never exceed the full voltage of a single fiber. It is comparable to a large 2 volt battery with thousands of 2 volt cells joined side by side. If the muscle fibers were arranged end to end in series, however, the action potential from such a large muscle would be quite impressive. This would be equivalent to a high voltage battery, with all the cells joined in series, end to end. This arrangement, in fact, is just that which exists in the electric organ and this is the secret of its power. While the potential difference of a single electroplate is only about 100 thousandths of a volt, there may be several thousand electroplates arranged in series in the electric organ. The total discharge of this entire organ is therefore several hundred volts.

Chemistry of the Living Battery

Recent biochemical investigations of electric organs have shown that their chemical processes resemble

those of nerve tissue or of striated muscle. Man-made batteries usually have dissimilar electrodes like carbon and zinc immersed in a jelly of some chemical salt. The theory of the way in which nervous impulses travel to muscles is very different and it is this which explains, to some extent, the living dynamo of the electric fishes. According to his theory, the passage of an impulse from nerve to nerve is the result of the release of a chemical called acetylcholine. However, when a nerve is stimulated it does not transmit a continuous electrical discharge, but only a very short one, lasting thousandths of a second. Obviously the acetylcholine first produced is destroyed again, otherwise the electrical discharge would continue. It is thought that an enzyme splits acetylcholine into its two constituent parts, choline and acetate. The splitting destroys its activity. But another enzyme, cholineacetylase, is able to rebuild acetylcholine from its fragments and so prepare for the next discharge at the nerve junction, or synapse.

Electric Organs Chemically Like Nerves

Since acetylcholine is easily broken down, its concentration in a living system must sometimes be inferred from that of the enzyme, cholinesterase. It has been shown that the concentration of this enzyme is directly proportional to the voltage in the electric organ of the electric eel. All of these observations together suggest that acetylcholine plays a part in the working of the electric organ which is at least as important as, and similar to, the one it plays in the machinery of the ordinary nerve and muscle system.

Fuel for the Machine

A question naturally arises as to the ultimate source of the very considerable quantities of energy involved in the discharge of the electric organ of a large fish. What is the fuel for the powerhouse? Since nerve, muscle and the electric organ have been shown to operate in basically similar fashion, it might be suspected that they use the same energy source. Recent research has suggested, in fact, that the common source lies in certain body chemicals with "high energy phosphate bonds." These can be broken down by specific enzymes and in doing so their energy is liberated in the form of muscular work, heat or electricity. The high energy bonds are then reformed by certain other specific enzymes by a process in which energy containing materials from the food in the blood stream is again incorporated into the molecule. Thus it is clear that the ultimate source of energy in these similar systems is the food consumed by the animal.

There is at present no general agreement about the exact molecular machinery of the generation of electric charges in the electric organ or even in nerve endings and muscles. It is apparently one of the peculiar properties formed in the membranes which separate all living cells. It is, perhaps, related to the nature of the electric charge on the membrane itself. Whatever turns out to be the final explanation for the generation

of an electric charge by these highly specialized organs, it is quite clear that this peculiar powerhouse has evolved independently in several groups of fishes. It is another illustration of the extreme variety of the complex machinery evolved by nature to accomplish the common aim of the nourishment and protection of animals.

It is an even better illustration of the far reaching influence of marine science. Studies of the electric organs of the salt-water electric ray, for instance, may well provide the basis for a better understanding of muscle and nerve behavior in human beings, thought at first they seem so widely different. The benefits arising from this are obvious.

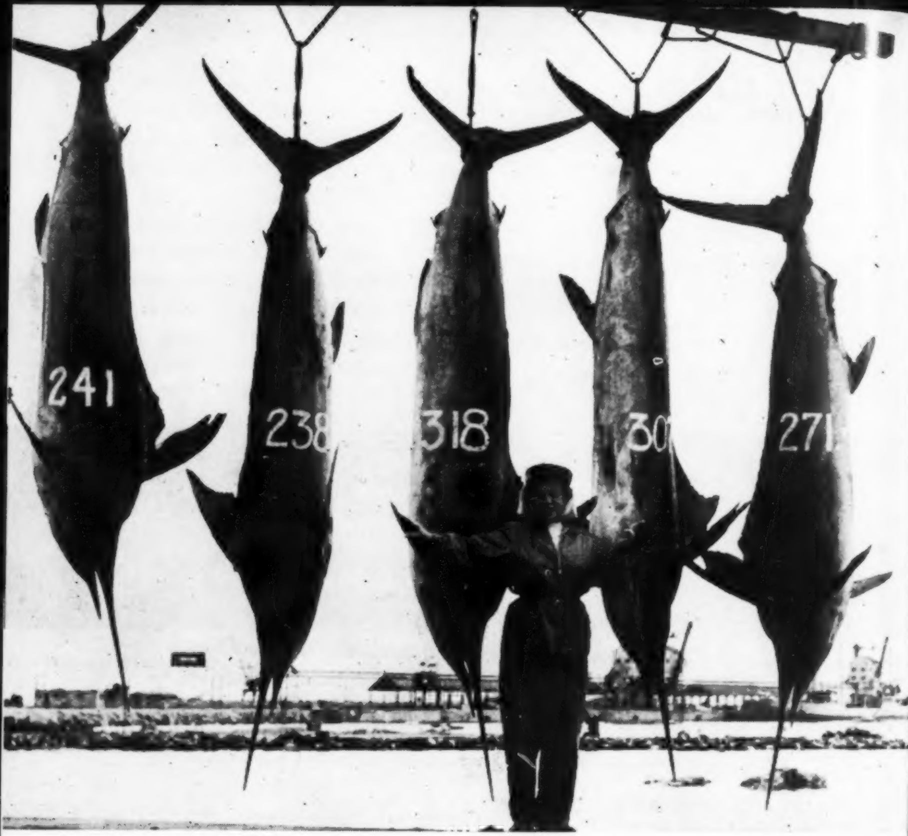
THE ELECTRIC EEL, Electrophorus electricus, *is actually a relative of the catfish. Note the elongated ventral fin. It produces a strong enough shock to stun a man.*

"*Animal Bushes*" *Of Palau*

BRILLIANT ORANGE "animal bushes," some as much as seven feet tall, are among the specimens of marine life collected in the Palau Island group of the Carolines, one of the American "trust territories" in the South Pacific, by Frederick M. Bayer, Smithsonian Institution biologist.

These sea bushes are colonies of coral animals, whose living tissues are a brilliant covering over a black, horny skeleton. They are called Antipatharia, a name derived from the Greek words for "against" and "suffering," because of the widespread folk belief that they are an antidote for any poison.

The island of Koror, where Bayer did most of his work, was the site of a former biological station established by the Japan Society for the Promotion of Scientific Research. Although the station was abandoned in 1944, Bayer believes Koror is the most favorable spot in Micronesia for biological studies.



Five striped marlin, *caught in one day by Mrs. Lou Marron, at Iquique, Chile, during the University of Miami-Lou Marron Expedition.*

Just What Is A Billfish?

By Edward C. Migdalinski
Bingham Oceanographic Laboratory

By simple definition, billfishes are large, spectacular, oceanic fish whose upper jaw is prolonged into a weapon commonly called a bill, spear, or sword. Well known members of this marine clan are sailfish, marlin, spearfish and swordfish.

But fishery technologists are still at odds concerning many points of identity among this large group of fishes. As this disagreement results in much confusion among anglers, it is obvious that much remains to be learned, both in the field and in the laboratory.

For instance, even the word *billfish* is a subject of lively controversy. Popular books on fishing, encyclopedias for anglers, and many other publications refer to the group as "speared fishes." The authors or editors contend that sailfish, marlin,

spearfish and swordfish should not be called billfishes because a subgroup of small silvery fish, such as houndfish, halfbeaks and needlefish, are named billfishes.

Billfishes and Beakfishes

Apparently such a conclusion leads only to more confusion. First, one member within this sub - group, *Strongylura marinus,* is called "billfish," an inconsistency that further adds to disorder in fish nomenclature. Secondly, one has never heard an angler, guide or boatman refer to these small fishes, some of which are used for bait, as billfish. They are always called ballyhoo, skippers, halfbeaks, scissors and other names, depending upon the locality.

Perhaps a better name for this now mixed-up assemblage of fishes would be "beakfishes." Billfish could then be used without confusion for the larger group of game fish.

Why abolish the "speared fishes" as applied to marlin and others? Chiefly because two members of this group are already called spearfish (Atlantic and Pacific forms). To add "ed" to spear, in order to differentiate between the groups and the particular species, also contradicts the beliefs and efforts of many advanced fishery workers, who advocate elimination of the suffix "ed."

Longnose or Longnosed Fish?

For example, the long nosed gar is now longnose gar; the largemouth is not large-mouthed; it is goosefish, not goosed fish! While many inconsistencies of this type remain, it is fairly obvious that the simpler forms are preferable.

Perhaps these reasons may seem to be a bit on the academic side, yet have you ever heard a mate yell: "Look at the spear!" Never. It is always "Look at that bill!", or "grab his bill," or "there's his bill." Therefore, it is believed that "billfishes" should replace "speared fishes" in referring to sailfishes, marlins, spearfishes and swordfish as a group.

Further, it is desired to suggest that the names of the Atlantic and Pacific spearfishes be changed to Atlantic shortbill marlin and Pacific shortbill marlin. If these proposals are adopted, it is felt that the present confusion regarding the common names of the billfish groups would be eliminated.

Report To Members

ANOTHER MILESTONE has been reached in the growth of *Sea Frontiers* towards its objectives of becoming a fully illustrated and authoritative magazine of exploration and research into the seas. With this number the editorial staff has been augmented by a full time associate in the person of E. John Long. He is well equipped in training and experience for the task that lies ahead.

Naval and Literary Career

Officially Captain Long first became associated with the sea when appointed to the Naval Academy in 1918. He later resigned to study at Columbia University, where he obtained the degrees of Bachelor of Arts and Bachelor of Literature. He has also attended Oxford University, in England.

During his career as a writer, he has been a newspaper reporter and correspondent with the *New York Times*, the United Press and the *Chicago Tribune*, as well as the *McKeesport Daily News*. From 1929 to 1940 he was a member of the editorial and executive staff of the *National Geographic Magazine*. His field activities with the *National Geographic Magazine* included membership of the Deep Sea Expedition headed by Dr. Beebe at Bermuda in 1934 and the Stratosphere Expedition in South Dakota in 1935.

Service in Two Wars

On November 16, 1937, Captain Long was appointed Lieutenant Commander in the U.S. Naval Reserve, and from June 10 to June 22, 1940 had active training duty in the Office of the Chief of Naval Operations. He was recalled to originate a Pictorial Section and has served as head of this section. Captain Long was a member of the Board to consider and report on the photographic needs of the Navy in July-August, 1941. On July 17, 1942, he was promoted to rank of Commander, U. S. Naval Reserve.

In April, 1942, he organized the Combat Art Section of Public Relations and he also served as general director of this section until he was detached from Public Relations. In February, 1945, he was ordered to report to the Superintendent of the Naval Academy, Annapolis, Mary-

land, and became assistant curator of the Museum. He was promoted to Captain in the Naval Reserve on January 15, 1946. Since then he has been employed as a civilian consultant in the Executive Office of the Secretary of the Navy, associated with Captain Walter Karig in the preparation of "Battle Report," a series of narrative histories of the U. S. Navy in World War II of which five volumes have been published.

Science Writing

As a civilian, John Long has written for numerous publications, chiefly in the transportation, travel and science fields. These include *New York Times, Collier's, National Geographic, Yachting, Ships & The Sea, Trains, U. S. Naval Institute Proceedings, Nature, Science Digest,* etc. In the "Around the World Program" of Doubleday & Company, New York City, he has authored: Mexico, Cuba, Holland, England and Central America (the latter in preparation).

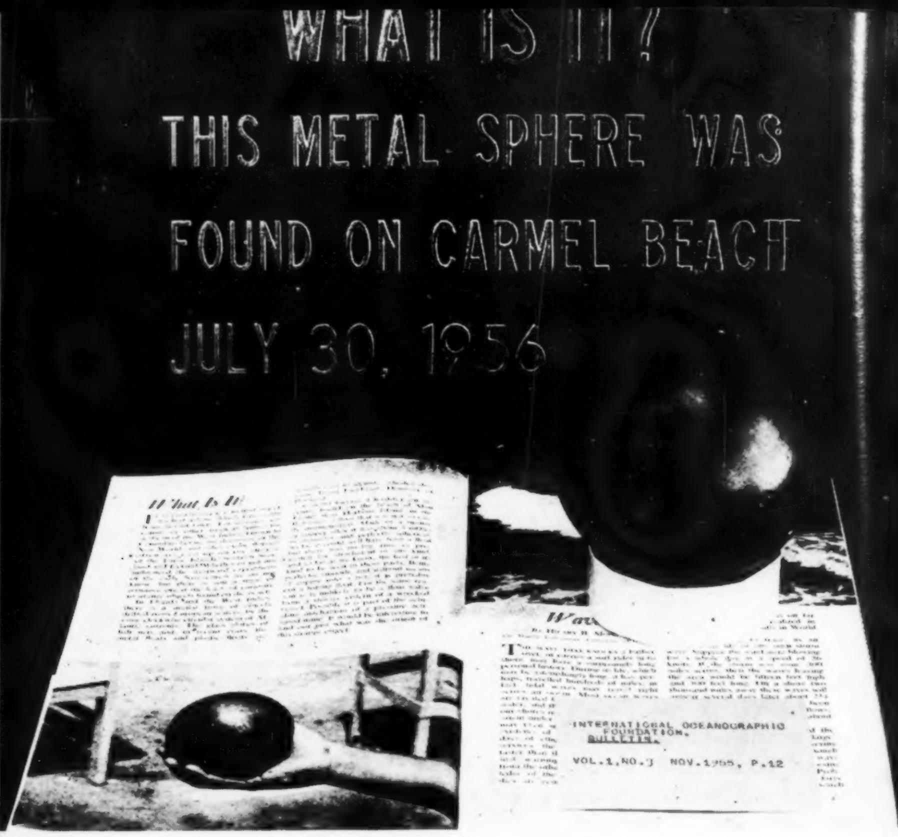
Looking Ahead

The future of *Sea Frontiers* will undoubtedly benefit by the presence of John Long on its permanent editorial staff. But other changes are also anticipated. It is hoped that articles from distinguished scientists throughout the world, written in a nontechnical fashion, will appear in increasing numbers as the staff becomes better equipped to organize publication and distribution.

Future articles already in preparation include such subjects as the effect of atomic energy activities on the ocean, minerals from the sea, new advancements in protection of ships and docks from corrosion and other forms of deterioration, new developments in navigation, and a series of science articles on the oceans for yachtsmen and fishermen, later to be published in book form. The series on sea monsters will also continue, along with news from the world's marine research laboratories.

More and more research is being directly supported by funds donated to the Foundation for these specific purposes. Progress in this will continue to be reported. The next number will include a preliminary notice on international meetings to be held concurrently for commercial fishermen and for deep sea anglers.

Letters received from members have been most useful to the staff and it is hoped that increasing numbers will take the opportunity of sending in their criticism, suggestions or requests.



The Mystery Continues!

IN NOVEMBER 1955 we published a brief article "What Is It?" describing a bronze or copper-alloy float found on the beach at Man Island, near Harbour Island, the Bahamas. This curious object, about five inches in diameter, had no lug, ring, or projection for attachment, and its possible use or function proved such a mystery that we printed a picture of it and invited our readers to send us any facts or theories concerning its origin.

Thus far there has been only one reply, from Morris Hoffman, associated librarian, U. S. Naval Postgraduate School, Monterey, California. Mr. Hoffman's letter, however, only deepens, rather than abates, the mystery. A similar metal ball, he reports, was picked up on the Carmel, California beach, on July 30, 1956. It has been placed on display, with a copy of the I.O.F. Bulletin, November, 1955, but thus far no one has been able to identify the object.

Science of the Sea in Books

THE GALATHEA DEEP SEA EXPEDITION, 1950-1952.

Described by members of the expedition; edited by ANTON F. BRUUN, SV. GREVE, HAKON MIELCHE and RAGNAR SPARCK. Translated from the Danish by REGINALD SPINK. Macmillan, New York, 1956. $8.00. Allen and Unwin, London, 40s.

Three years ago an account was published in Danish of a remarkable deep-sea expedition. Judged in the light of the previous meager knowledge of the life of the deepest sea floor, the accomplishments of the *Galathea* expedition were most impressive. The story of this is now available in the English version. It is written for the general reader as well as for the scientist and is profusely illustrated. Not only those interested in the deep sea and its living creatures but those interested in sea snakes, birds, native customs and exotic trees will find much to interest them.

When the expedition was planned, very little was known of the creatures living in depths of 2,000 fathoms or more. Nothing at all was known of the sea floor below 4,000 fathoms. The first animals ever to be taken from the enormous depth of 10,190 meters or about six miles, were brought to the surface by the *Galathea* expedition from the Philippine Trench in July, 1951.

Each of the chapters is written by one or the other of the participat-

DEEP SEA ANGLER FISH *taken by* Galathea *in the Gulf of Panama.* Borophryna *is its name. It has a "lamp" on the nose and a dwarf mate may be seen attached to this female horror on the lower rear surface.*

ing scientists, so that many points of view are sampled and the highlights of the expedition well covered. For instance, Claude ZoBell and Richard Morita, who joined the expedition from the U.S.A., describe the abundant bacteria of the deep sea which not only are able to withstand the enormous pressure of seven tons to the square inch, but actually prefer it. In contrast to this, H. Volse devotes a chapter to the sea snakes which he collected in the surface waters of the Indian Ocean and which provoked at least one "incident" on board.

The objects of the expedition and the animal life on the sea floor are described in an interesting and enthusiastic manner by Anton Bruun, the leader, whose personal energy no doubt communicated itself to his fellows and had much to do with the success of the voyage.

Other chapters deal with the difficult technique of trawling at great depths, the echo sounding studies, investigation of terrestrial magnetism below the sea surface and the measurement of organic productivity. It is an unusually readable book.

THE LIVING SEA

JOHN CROMPTON. Collins, London, 1957. 15s. net. ($2.10.) Doubleday, N.Y., $3.95.

Another of the long line of books about the sea which has appeared during the last ten years, *The Living Sea* will interest the general reader more than the biologist. In an exciting and somewhat informal style the author leads the reader from the formation of the oceans, through the origin of life in the sea, to the appearance of land life. Particularly interesting are the chapters dealing with the exodus of animals from the sea to land and their strange journey back to the parent ocean. Evolutionists and behaviorists may object to some of the lines of reasoning presented, but they do not detract from the general information.

A large part of the book is devoted to the whales and sharks and many strange and lesser known facts are included. Unfortunately some errors and exaggerations have slipped past the author, for we see such statements as that fish are 99 per cent water, that the right whale is extinct, and the gray and sperm nearly so. Mr. Crompton is a conservationist at heart and we cannot help but agree with him in many of his statements concerning the danger of extinction of many forms of marine life, even though the danger is sometimes more imaginary than real.

The fish section is well done, though lightly, but the invertebrates are relegated to only two chapters dealing almost exclusively with shrimps, lobsters, crabs and mollusks or sea shells. Of interest to most will be the amusing cases of intimate relationship between certain crabs and sea anemones, the antics of hermit crabs exchanging shells and the portable houses of the sponge crabs. The author goes somewhat astray in speaking of Portuguese man-of-war over a yard in diameter and bath sponges having glasslike spicules when living. There are other errors. Collectors of the showy and beautiful land snails of the tropics will be surprised to learn that, according to the author, only a few species of mollusks have been able to adapt to terrestial conditions. Other readers may be set to searching for pearls of great value in their oyster stew—in vain.

The author is one of the few popular writers on the sea who has been able to deal with the subject in a dynamic fashion. The breeding and migration of the herring and cod, the spawning of the oyster, the importance of the floating plants in the food chain of the sea, and the entire picture of marine life in its ever changing and closely linked relationship to man are presented with vividness and sincerity. This is perhaps more important to the general reader than the occasional lapses in scientific accuracy. G.L.V.

TRAIL BLAZER OF THE SEAS

JEAN LEE LATHAM. Houghton Mifflin Company, 1956. $2.75.

This is a book for children of high school age, but it is nevertheless a well written account of the career of Matthew Fontaine Maury, who has been called the Father of American Oceanography. It is recommended to adults as well as children who are interested in sailing, or in the history of navigation on the high seas.

Maury, like many great men before and after him, had to fight authority in order to have his ideas accepted. He was even, for a brief time, placed on the Retired List of the U.S. Navy in order "to promote the efficiency of the Navy" after receiving civic and scientific honors both from the U.S.A. and other countries in recognition of his work. He was reappointed, with promotion in rank, to the Active List.

Maury founded the work of compilation which led to the Hydrographic Office Wind and Current Charts, which marked a tremendous advance in the navigation of his time and also promoted international cooperation in exchange of the necessary data. He fought, not only for this, but also for the setting up of separate east and westbound steamship lanes in the North Atlantic. With the sounding apparatus developed by John Brookes, he was able to pave the way for the laying of the transatlantic cable. He also laid the foundations for international cooperation in meteorology and helped to found the Naval Academy at Annapolis.

There is nothing technical about this book but, even though written for children, a grown scientist should find it interesting reading. Jean Lee Latham, the author, also wrote "Carry On, Mr. Bowditch," the fictionized biography of Nathaniel Bowditch, the great navigator, which received the 1956 John Newbery Award for the most distinguished contribution to American literature for children.

"Of Whales and Men"

OUR ATTENTION is drawn by Chr. Salvesen & Co., deep sea factory operators, of Leith, Scotland, to the review of "Of Whales and Men," in our issue of July 1956. In particular, a statement in the book to the effect that four British whaling expeditions contribute annually about $180,000,000 is disputed. The facts, according to our informant, are that this sum is considerably higher than the total value of the twenty expeditions, manned by various nationalities, now operating in the Antarctic. It is also noted that a profit of $10,000,000 on a single voyage is exaggerated, and that it is rarely possible to earn even a tenth of this sum.

Progress

In the short period of its life, the Bulletin has now reached a circulation of 12,000, not all of whom are members. They are drawn from the United States, Canada, Central and South America, Great Britain, Australia, France, Germany, Italy, Denmark, Sweden and Norway, as well as a few from the Pacific Islands and the West Indies. Continued improvement will be possible with growth of active membership. It will be seen in better service, with more articles in the Bulletin of high interest and authenticity and, eventually, a monthly issue in full color.

Members are joined in these aims and they are urged to make progress possible by taking the small effort needed to enlist new members. To those who are not members, but whose interest and curiosity lie in the sea and the spirit of discovery, there is extended an invitation to participate by simply mailing a card. The ocean is our last frontier and its exploration still under way.

The editor will be glad to consider for publication articles and illustrations covering explorations, discoveries or advances in our knowledge of the marine sciences or describing the activities of oceanographic laboratories or expeditions in any part of the world.

ACKNOWLEDGMENTS

Front and back covers, Charles E. Lane. Inside front cover, U. S. Navy. Pages 66, 68, U. S. Dept. of Interior; Page 69 DuPont; Pages 70, 71, U. S. Army; Page 91, Frederick M. Bayer; Pages 98, 99, 100, 101, 102, 103, 104, 105, 106, 107, 108, International Pacific Salmon Fisheries Commission; Page 113, Christopher Coates; Pages 115, 116, Royal College of Surgeons, Miss J. Dobson and Mr. Edwards; Page 119, Smithsonian Institution.

The International Oceanographic Foundation

"To encourage the extension of human knowledge by scientific study and exploration of the oceans in all their aspects, including the study of game fishes, food fishes, ocean currents, the geology, chemistry, and physics of the sea and the sea floor."

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The Foundation was established by a group of saltwater anglers, yachtsmen, shipowners, marine scientists and others interested in the scientific exploration of our last frontier, the ocean. Its objectives are to provide support and encouragement for marine research, exploration and discovery and to promote the collection and dissemination of scientific knowledge about the ocean.

Qualifications for membership are an interest in the oceans and a desire to extend and develop scientific research and exploration into them. Support given to research through personal activities or donations is recognized by the Foundation through the following classes of membership. Members are those who make annual contributions of $5, Fellows $25 annually; Life Fellows are those who contribute $200 or more or who have otherwise helped to advance the purposes of the Foundation; Sponsors who contribute $1,000 or more; and Patrons who contribute $5,000 or more.

According to a ruling of the U.S. Treasury Department, donations made to the Foundation are deductible in computing taxable income as provided for by the 1954 code.

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